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16. Abstract

The results of the Coast Guard Research and Development Center's Operational and Technical Evaluation of the 110-foot Bell-Halter SES are reported. The testing included evaluations of deck area and internal volume, speed versus power, fuel consumption, towing capability, maneuverability, time to get underway, and visibility from the deckhouse. Moment to heel, motion in waves, sail area, susceptibility to slamming, performance in astern seas, and watertight integrity are also studied together with hull vibrations level, handling pollution gear, boom capability, and secondary variables. The Operational Evaluation (OPEVAL) covered the areas of seakeeping characteristics, habitability, equipment arrangement, mission support capability, boat launching, survivability, interoperability and logistics, maintainability and anchoring. Recommendations for improving test procedures and equipment have been included as an appendix to this report. Computer programs for collecting and evaluating the data are also given. A new procedure for performing inclining experiments is described.

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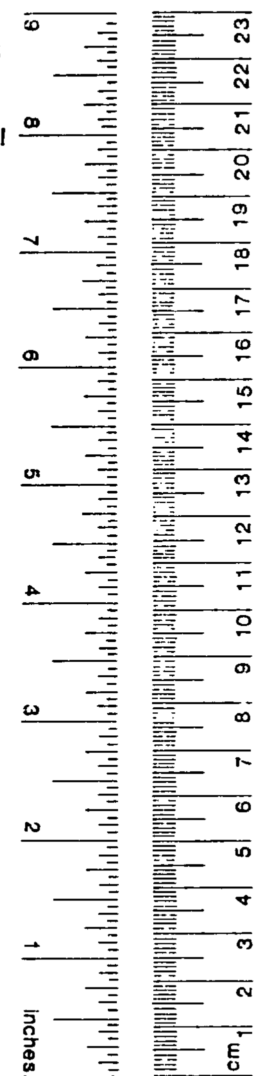
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

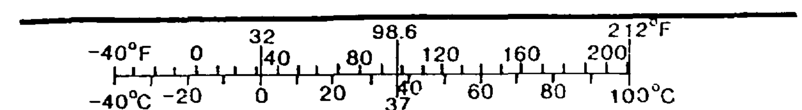
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25. SD Catalog No. C13.10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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ABSTRACT

The results of the Coast Guard Research and Development Center's Operational and Technical Evaluation of the 110-foot Bell-Halter SES are reported. The testing included evaluations of deck area and internal volume, speed versus power, fuel consumption, towing capability, maneuverability, time to get underway, and visibility from the deckhouse. Moment to heel, motion in waves, sail area, susceptibility to slamming, performance in astern seas, and watertight integrity are also studied together with hull vibrations level, handling pollution gear, boom capability, and secondary variables. The Operational Evaluation (OPEVAL) covered the areas of seakeeping characteristics, habitability, equipment arrangement, mission support capability, boat launching, survivability, interoperability and logistics, maintainability and anchoring. Recommendations for improving test procedures and equipment have been included as an appendix to this report. Computer programs for collecting and evaluating the data are also given. A new procedure for performing inclining experiments is described.

1.0 INTRODUCTION

The prototype 110-foot surface effect ship (SES) manufactured by Bell-Halter has been purchased by the U.S. Navy. Under an agreement with the Navy the U.S. Coast Guard was allowed to use the vessel for an Operational Evaluation (OPEVAL) and Technical Evaluation (TECHEVAL) over a 6-month period from June to December 1981. During this time the SES was operated as a replacement for an 82-foot patrol boat (WPB) and was commissioned as the USCGC DORADO (WSES-1).

The Coast Guard Research and Development Center (R&DC) performed tests on the vessel during two TECHEVAL periods, one in August 1981 and one in November 1981. This report documents the results of the Coast Guard Research and Development Center efforts during these periods. The OPEVAL was essentially conducted by the crew of the DORADO. Their comments on the multitude of factors which must be evaluated were collected through the use of questionnaires during the TECHEVALs. The DORADO was operated by Commander, Eighth Coast Guard District (CCGDEIGHT). All photographic support was handled by CCGDEIGHT.

R&DC performed this work as part of the Advanced Marine Vehicles and Ship Trials Program. This report contains the results of the TECHEVAL tests and the compiled responses to the questionnaires used to collect data for the OPEVAL. The testing included evaluations of deck area and internal volume, speed versus power, fuel consumption, towing capability, maneuverability, time to get underway, and visibility from the deckhouse. Moment to heel, motion in waves, sail area, susceptibility to slamming, performance in astern seas, and watertight integrity are also studied together with hull vibrations level, handling pollution gear, boom capability, and secondary variables. The OPEVAL covered the areas of seakeeping characteristics, habitability, equipment arrangement, mission support capability, boat launching, survivability, interoperability and logistics, maintainability and anchoring. Recommendations for improving test procedures and equipment have been included as an appendix to this report.

2.0 DESCRIPTION OF THE SES

The USCGC DORADO (WSES-1) is a 110-foot SES manufactured by Bell-Halter. It is a high performance, surface-effect ship capable of on-cushion speeds approaching 30 knots with a minimum load in calm water. The craft rides on a resistance-reducing cushion of air trapped between rigid sidewalls and bow and stern flexible seals.

The vessel is shown in profile in Figure 1. Deck views are shown in Figures 2, 3, and 4. An inboard profile is shown in Figure 5. Figure 6 shows the seal system used. Cushion air is supplied by centrifugal fans to the cushion through longitudinal ducts to orifices aft of the leading edge of the bow-fingers, amidships through the bottom wet deck, and aft into the stern seal bags.

The SES is admeasured under 100 gross tons and has received a U.S. Coast Guard certificate of inspection for operation in ocean service. Principal characteristics of the SES are given in Table 1.

TABLE 1
PRINCIPAL CHARACTERISTICS OF 110-FOOT SES

Dimensions			
Length overall (LOA)			109'-2"
Length between perpendiculars (LBP)			93'-6"
Beam (Max)			39'-3"
Depth			15'-1"
Draft (Light Ship)	OFF CUSHION		7'-0"
	ON CUSHION	Approx.	3'-0"
(Full Load)	OFF CUSHION		8'-5"
	ON CUSHION	Approx.	4'-5"
Freeboard (Light Ship)	OFF CUSHION		8'-1"
	ON CUSHION	Approx.	12'-1"
(Full Load)	OFF CUSHION		6'-8"
	ON CUSHION	Approx.	10'-8"
Radar antenna height (above full load WL on cushion)			33'-6" top 30'-9" btm
Height of eye on bridge (5'-6" above deck on cushion)			25'-0"
Minimum operating depth			9'-5"
Leading Particulars			
Displacement (Light Ship)			99.6 L.T.
(Full Load)			150.3 L.T.
Crew			8-14

Machinery

Propulsion - Two 16V 149TI Detroit diesel marine engines (each 1440 SHP @ 1900 RPM, 180 injectors)

Two 41.9-inch diameter x 50.5-inch fixed pitch propellers.

Lift - Two 8V 92TI Detroit diesel marine engines (each 435 SHP @ 2100 RPM, 9290 injectors)

Two double width-double inlet centrifugal 42-inch diameter fans

Generators - Main = 55 KW
Standby = 40 KW

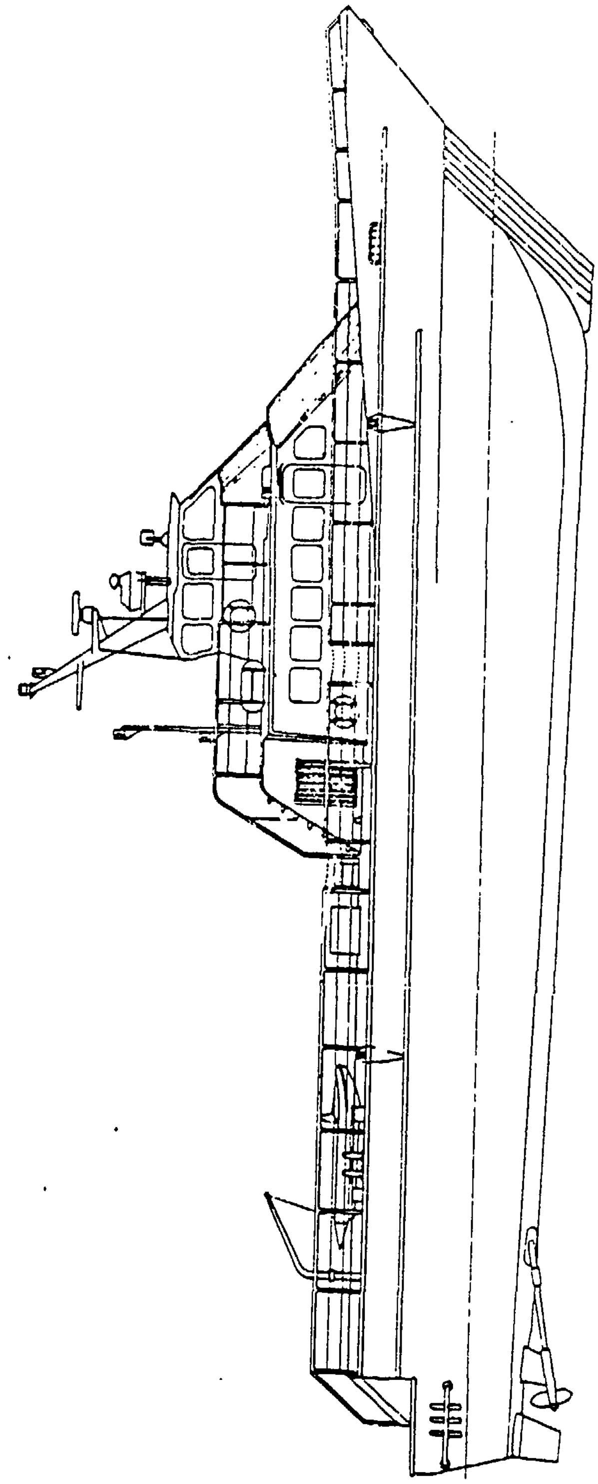


FIGURE 1
OUTBOARD PROFILE

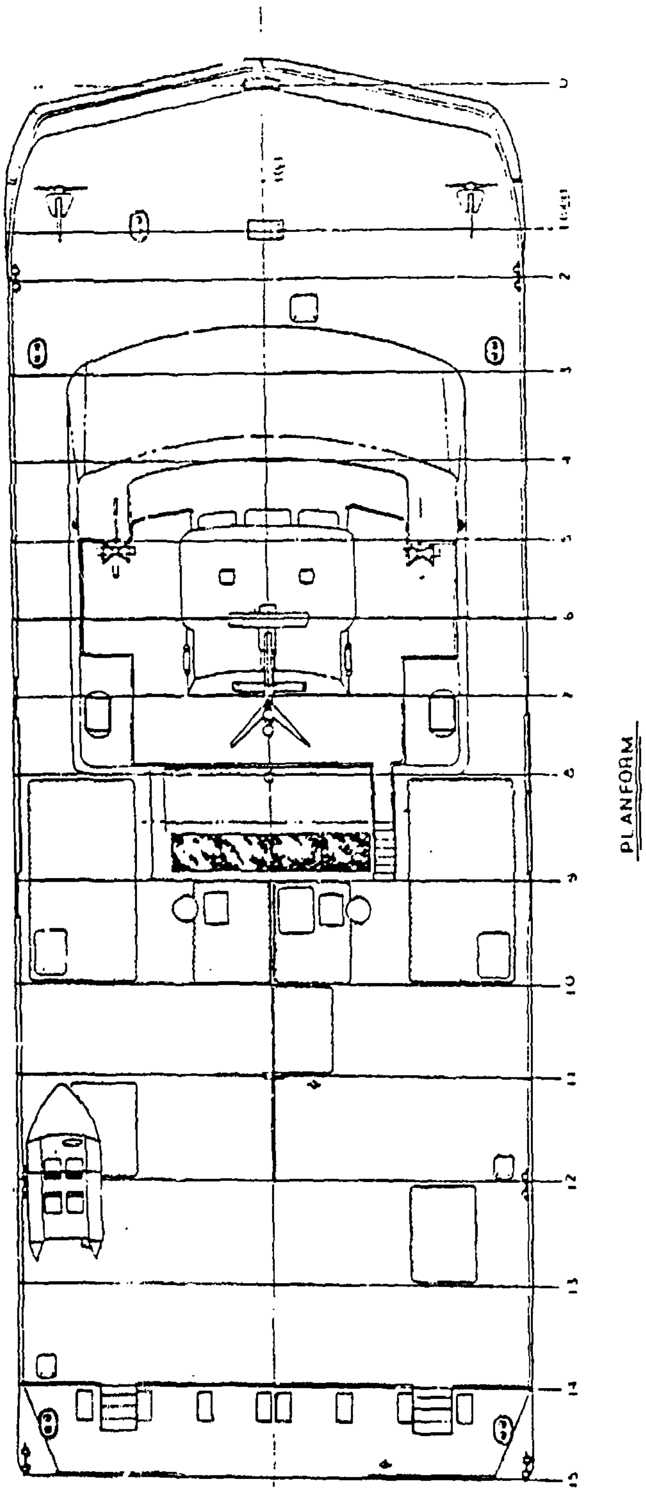


FIGURE 2
EXTERNAL DECK PLAN

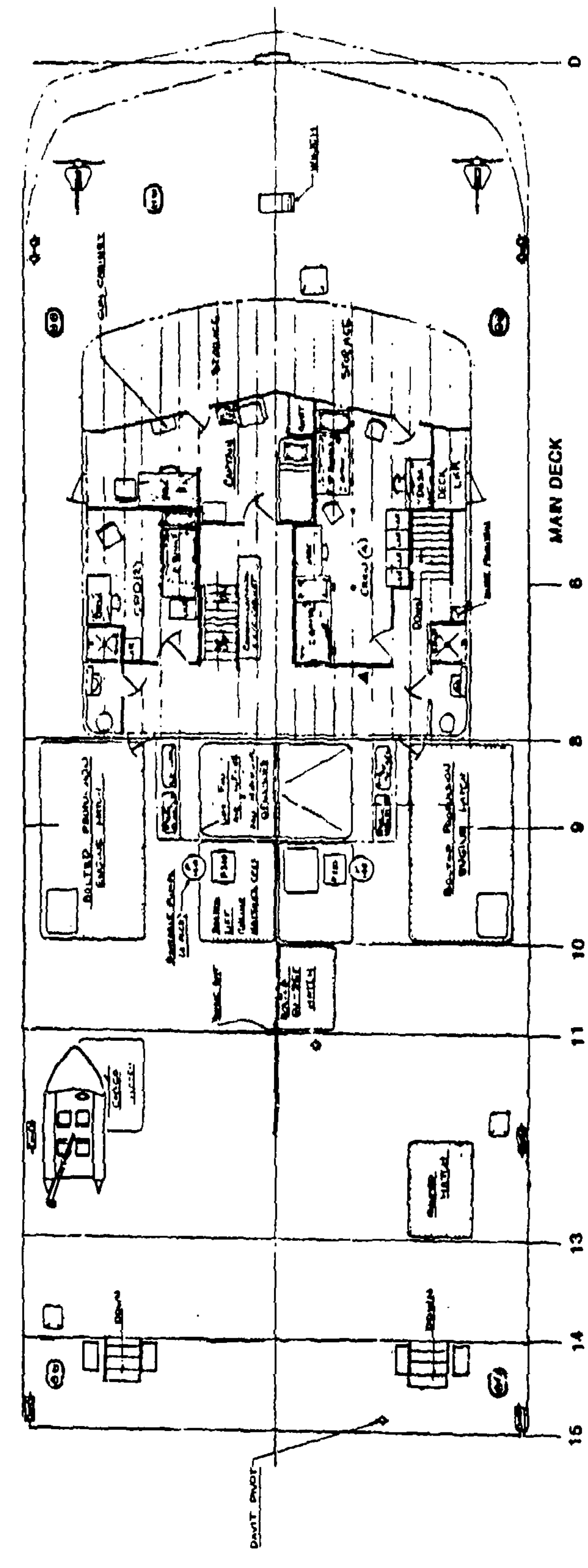


FIGURE 3
MAIN DECK PLAN VIEW

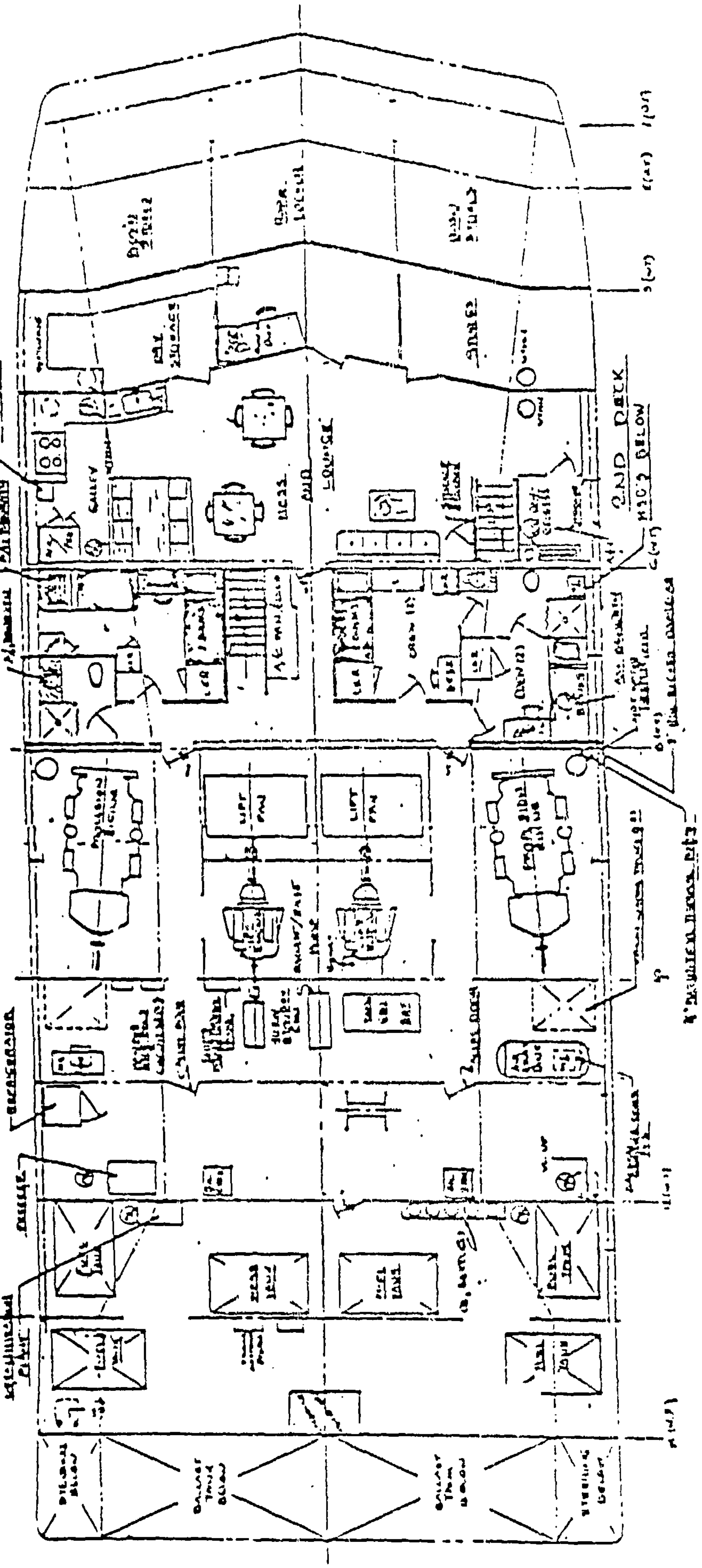


FIGURE 4
1st DECK PLAN VIEW

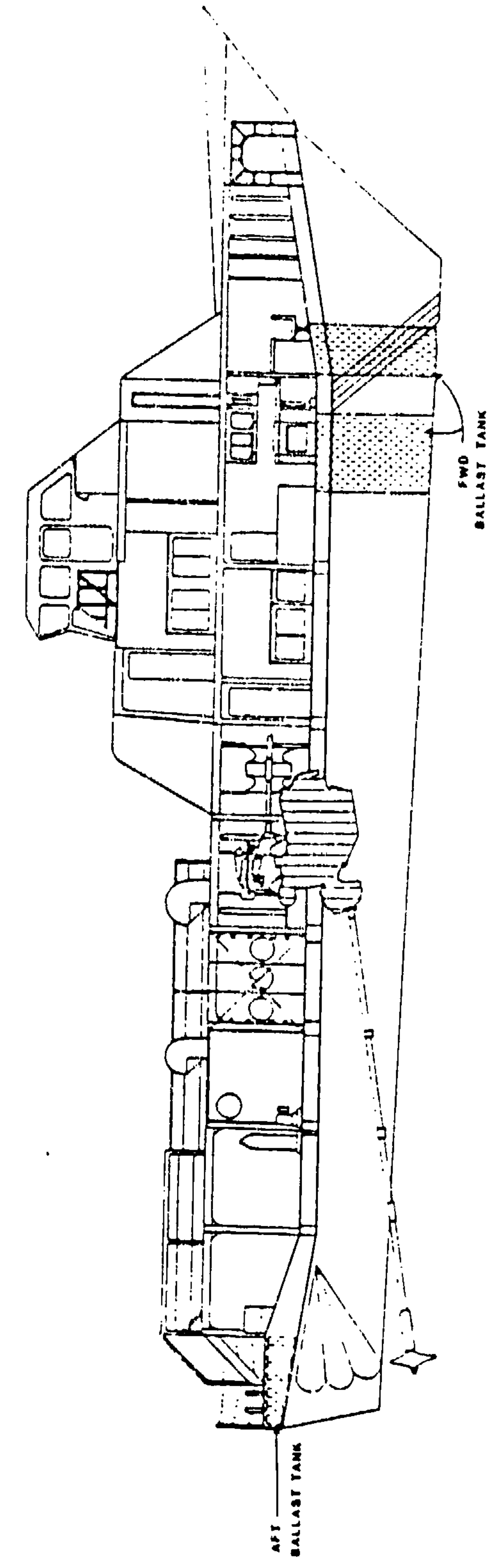


FIGURE 5
INBOARD PROFILE

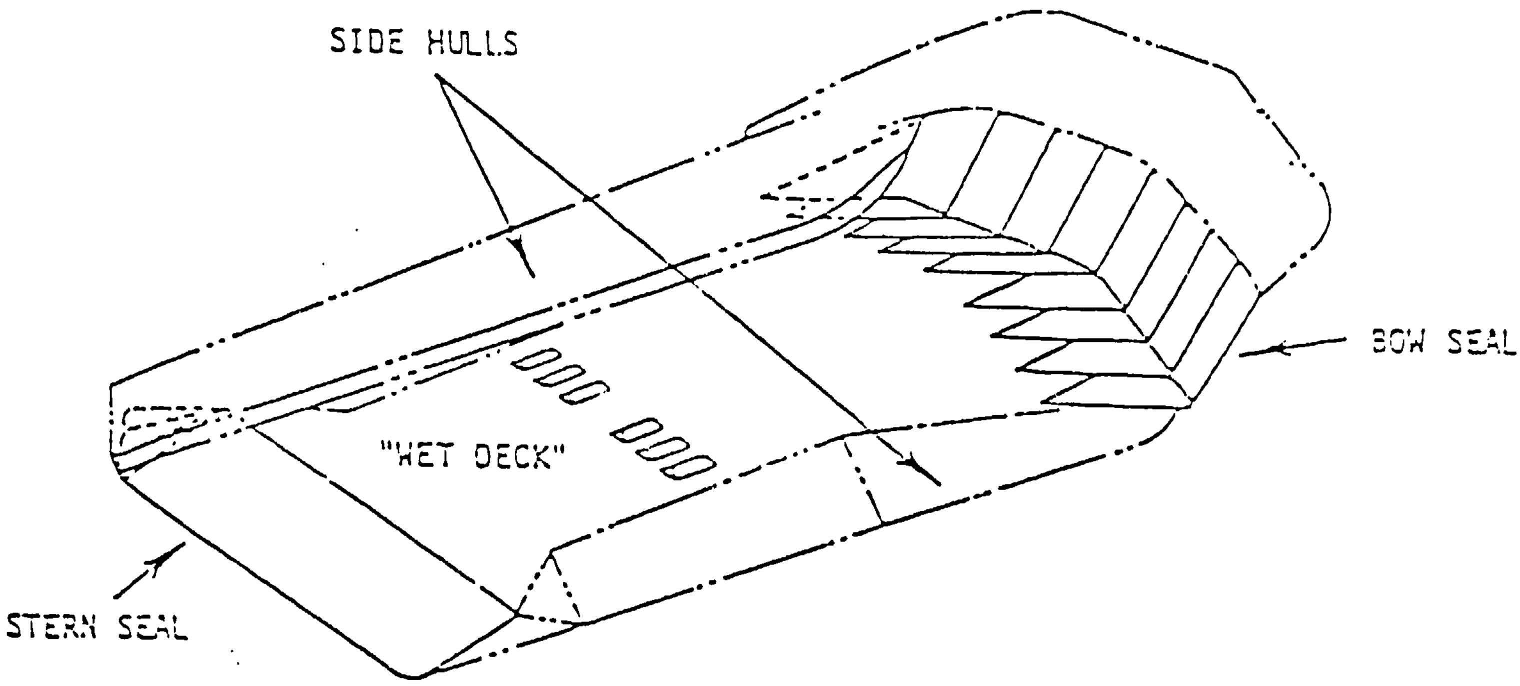


FIGURE 6
BELL-HALTER 110-FOOT SES SEAL SYSTEM

3.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions on each trial are included in the test results section of this report. The more important of these will be discussed here.

Very few modifications were required to convert the demonstration craft manufactured by Bell-Halter into an operational Coast Guard cutter. The major modifications included additional accommodations, adding a towing bitt, and providing a 4-meter AVON small boat. The 110-foot SES performed very well during the OPEVAL period and experienced few serious problems. It was generally praised by the crew as a significant improvement over current patrol boats.

Several design problems do exist, however. The most serious of these are:

The hull was made as light as possible to reduce powering and lift requirements. In several areas, but particularly near the after ballast tanks, hull cracking was a recurring problem. Overall the hull was of adequate strength but in many areas the strength was inadequate.

During most Coast Guard operations the vessel operated at a full load displacement of 150 tons. Design displacement is 125 tons. At full load displacement engine power was marginal to drive the vessel past hump speed. This is the speed at which the vessel begins to exhibit a reduced power requirement with increasing speed. When towing and when not at optimum trim it was often impossible to achieve hump speed. The benefit from getting over hump speed is large; therefore, sufficient power should be installed to achieve this speed under sub-optimal trim and light tow loads such as the Coast Guard's high-speed delivery sled.

Propeller design is another area of concern. The original propellers had severe cavitation problems. The present propellers are fixed pitch and operate near the upper limit of performance for subcavitating propellers. Modifications to the original propellers were made to delay cavitation. The propeller diameter was reduced by almost 2 inches and three (3) 3/8" diameter holes were drilled at the root of each blade for venting. After several hundred hours under various loading conditions, the present propellers show no signs of cavitation. The propellers used are optimized for speed. As a result their towing performance suffers considerably. Dual pitch or variable pitch propellers may offer improved towing performance at a minimum loss of high-speed performance.

Maintenance requirements for the bow and stern seals does not appear to be excessive. However, a longer period of operation is needed to quantitatively determine the actual seal maintenance requirements.

The sail area of the SES is considerably larger than current patrol craft. This is particularly true on cushion. No serious windage or side slip problems were noted but the high profile combined with the spray from the cushion makes the SES visible from a greater distance.

In all other areas studied, the SES performed as well as or better than WPBs. Of particular note are its high speed, low fuel consumption, and excellent maneuverability. The primary advantage an SES has over a displacement vessel is its significantly greater speed for the same installed horsepower. The SES provides a roomy and very stable platform. Although vertical accelerations are a problem in high seas, the SES is able to operate in much higher seas than conventional craft of like size. Habitability was a vast improvement over 82-foot WPBs. No problems were experienced in operating the DORADO with other Coast Guard units.

In summary, the surface-effect ship concept appears to be a strong contender as a possible replacement for current cutters. Further studies should be performed to determine the optimum power and propeller characteristics.

4.0 TEST RESULTS

4.1 Deck Area and Internal Volume

Various internal volumes and deck areas as required in Test 2 of the General Test Plan were measured from plans provided by Bell-Halter. These are tabulated in Table 2. The special use suitability is subjective. The minimum values given represent approximately the volume/area which can be used for no other purpose than that listed. Maximum values include many overlapping areas/volumes. Choosing the use of each area requires trade-offs between conflicting uses for the space. Also, more internal area can be obtained by reducing the external deck area.

TABLE 2
DECK AREA AND INTERNAL VOLUME

USCGC DORADO (WSES-1)

Total enclosed volume of hull		31500 cu ft
Total enclosed volume of deckhouse		8400 cu ft
External deck area	Aft platform	270 sq ft
	Main deck	2490 sq ft
	01	400 sq ft
	02	120 sq ft
Internal deck area	01	100 sq ft
	Main	1160 sq ft
	1	3350 sq ft

Special use suitability	Max Area/Vol	Min Area/Vol
a. Liquids	13800 cu. ft	5500 cu. ft
b. Accommodations, etc.	1770 sq. ft	800 sq. ft
c. Machinery Spaces	1990 sq. ft	870 sq. ft
d. OPS and Communications	1500 sq. ft	700 sq. ft
e. Pilot House	700 sq. ft	700 sq. ft
f. Provisions and Cargo	2060 sq. ft	360 sq. ft
g. Stacks and Uptakes	140 sq. ft	140 sq. ft
h. Boat, Helo and AtoN	1500 sq. ft	0 sq. ft
i. Ground Tackle	100 sq. ft	0 sq. ft

4.2 Speed vs. Power

Speed/power trials were conducted previously by the Naval Sea Systems Command (NAVSEASYSCOM) Detachment in Norfolk, Virginia. A trial was conducted in accordance with Test 3, Speed versus Power, of the General Test Plan primarily to verify this previous work. Speed and power were measured both on cushion and off for a displacement between the two displacements previously tested.

The results of this test are shown in Figures 7 and 8. When these results are compared to the previously reported results, a large discrepancy will be noted. During our trial runs the vessel was never able to achieve hump speed and peaked at a speed of slightly more than 22 knots. Possible explanations for this performance are non-optimal trim of the vessel or an increase in bottom fouling. During our tests the trim was approximately 0.1 degrees versus 0.6+ degrees used during the Navy tests. Experience with the craft has shown it to be extremely sensitive to trim. However, prior to conducting the trials the trim was adjusted to get the maximum speed with seemingly little effect. The amount of bottom fouling was unknown. There is not enough information to attribute a cause to this transitory problem.

Torque was measured during the test runs using Ultra Product Systems, Inc. horsepower measuring equipment. Serious problems were experienced with this means of measuring torque. These problems and recommendations for improvements are discussed in Appendix C.

Observations made during the DORADO tests and the results of these speed/power trials illustrate one very important difference between the performance of SES's and displacement vessels. Namely, on a displacement craft the loss of 50 percent of power may only result in a speed loss of 10-20 percent, while on an SES the effect can be much greater. If an SES such as the DORADO were to lose one engine it could not get over hump speed and the speed loss will be 50 percent or greater. This effect becomes more pronounced in faster SES's. Also, there must be an adequate power margin to drive the vessel past hump speed even in non-optimum conditions. The DORADO clearly does not possess this margin as illustrated by the speed/power trials performed.

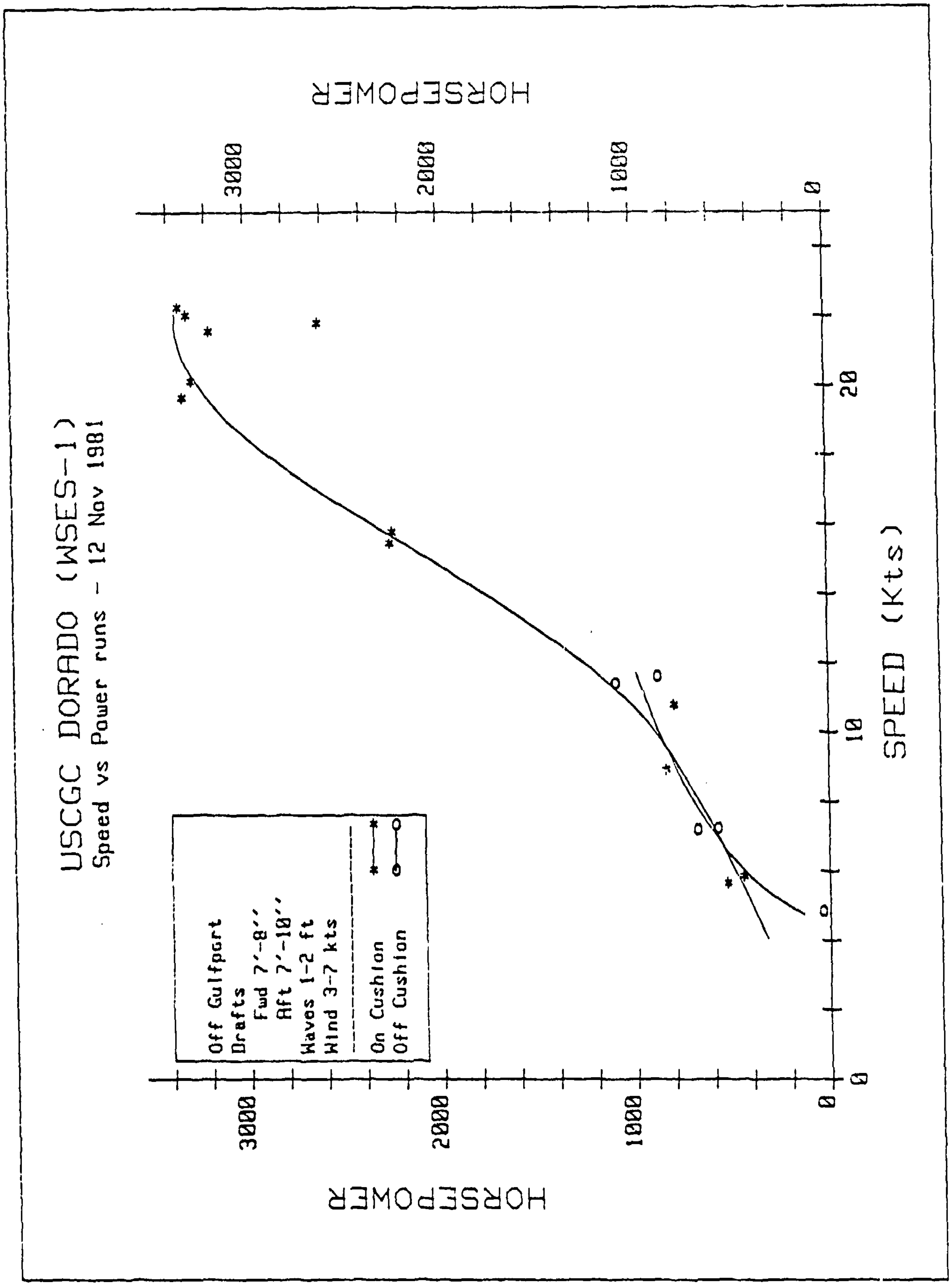


FIGURE 7
SPEED VERSUS HORSEPOWER

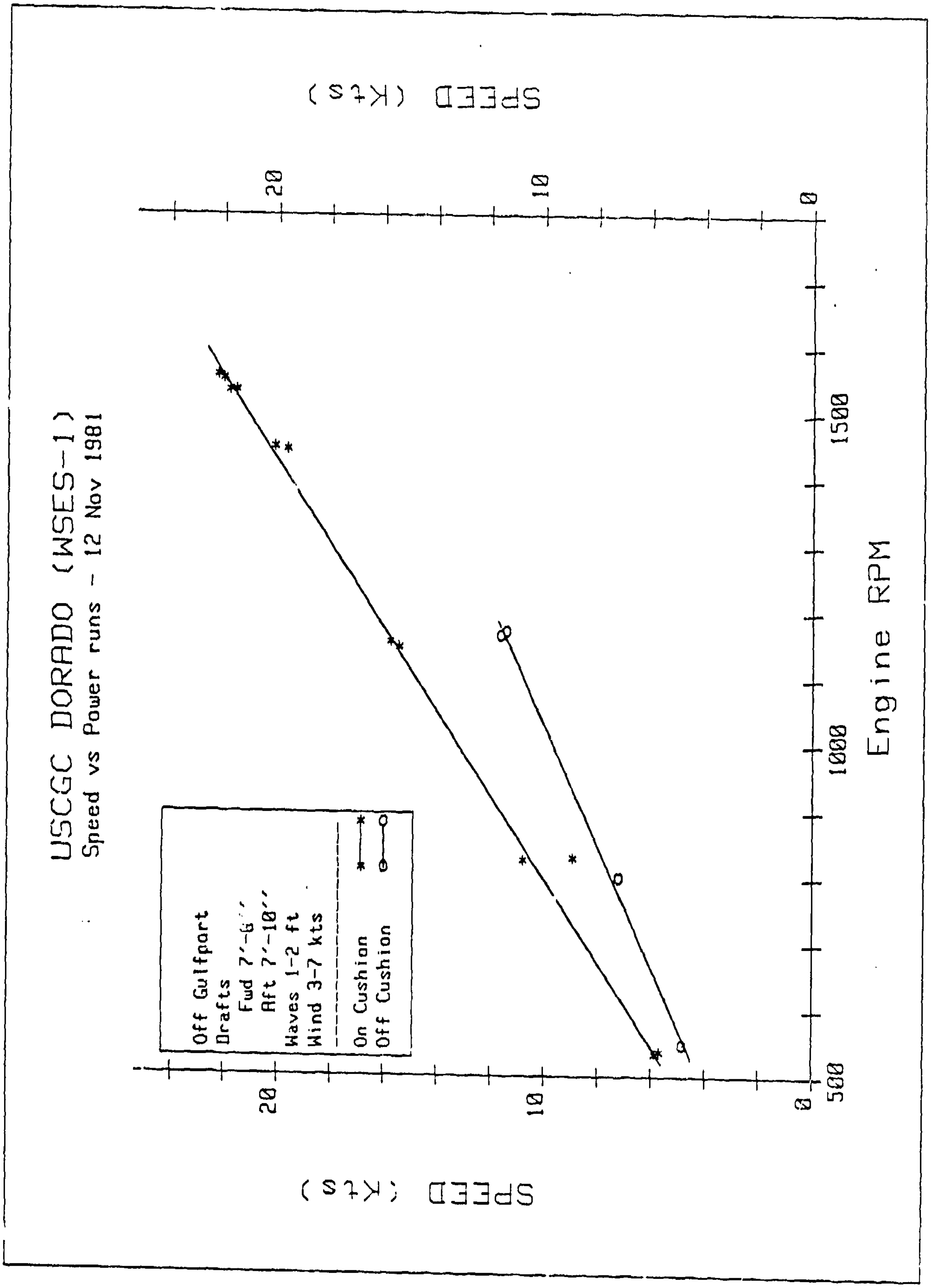


FIGURE 8
ENGINE RPM VERSUS SPEED

4.3 Fuel Consumption

A modified version of Test 4, Fuel Consumption, was performed. This was done to verify the accuracy of the results obtained by the Naval Sea Systems Command during testing on 19-20 February 1980. Informal observations of fuel consumption during the OPEVAL indicated a lower fuel consumption. The confirming tests were performed on 3 December 1981. A shaft torsion meter was not installed during the tests so shaft horsepower is not available.

In-line fuel flow indicators (gal/min) were installed on both the supply and the return fuel lines of the two main propulsion engines and the two lift fans. The fuel consumption of the generator was ignored. RPM's were measured on both propulsion shafts and both lift fan shafts. A two nautical mile measured run was used. Runs were made in both directions at the same throttle setting. The results were recorded and the average over the two runs was used to minimize the effects of wind and current.

The results of the tests are shown in Figures 9 and 10. Additional data is contained in Appendix A, Table A-1. The fuel consumption data gathered by NAVSEASYSCOM was confirmed by these tests. The fuel consumption curve based on gal/nm is very flat over the operating range of the DORADO. This permits transitting at maximum speed with no greater fuel consumption than when travelling slowly.

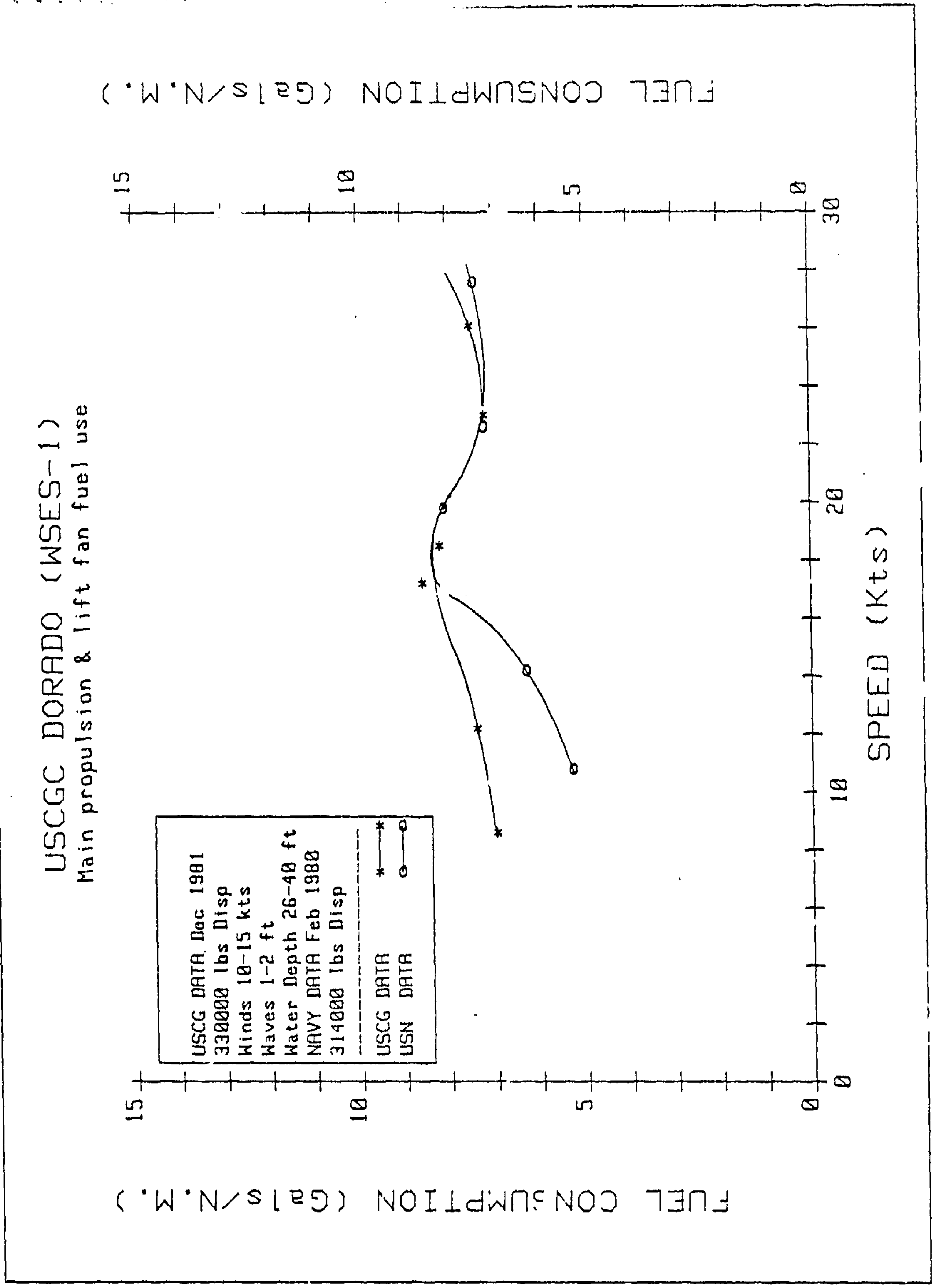


FIGURE 9
FUEL CONSUMPTION (GALS/NM) VERSUS SPEED

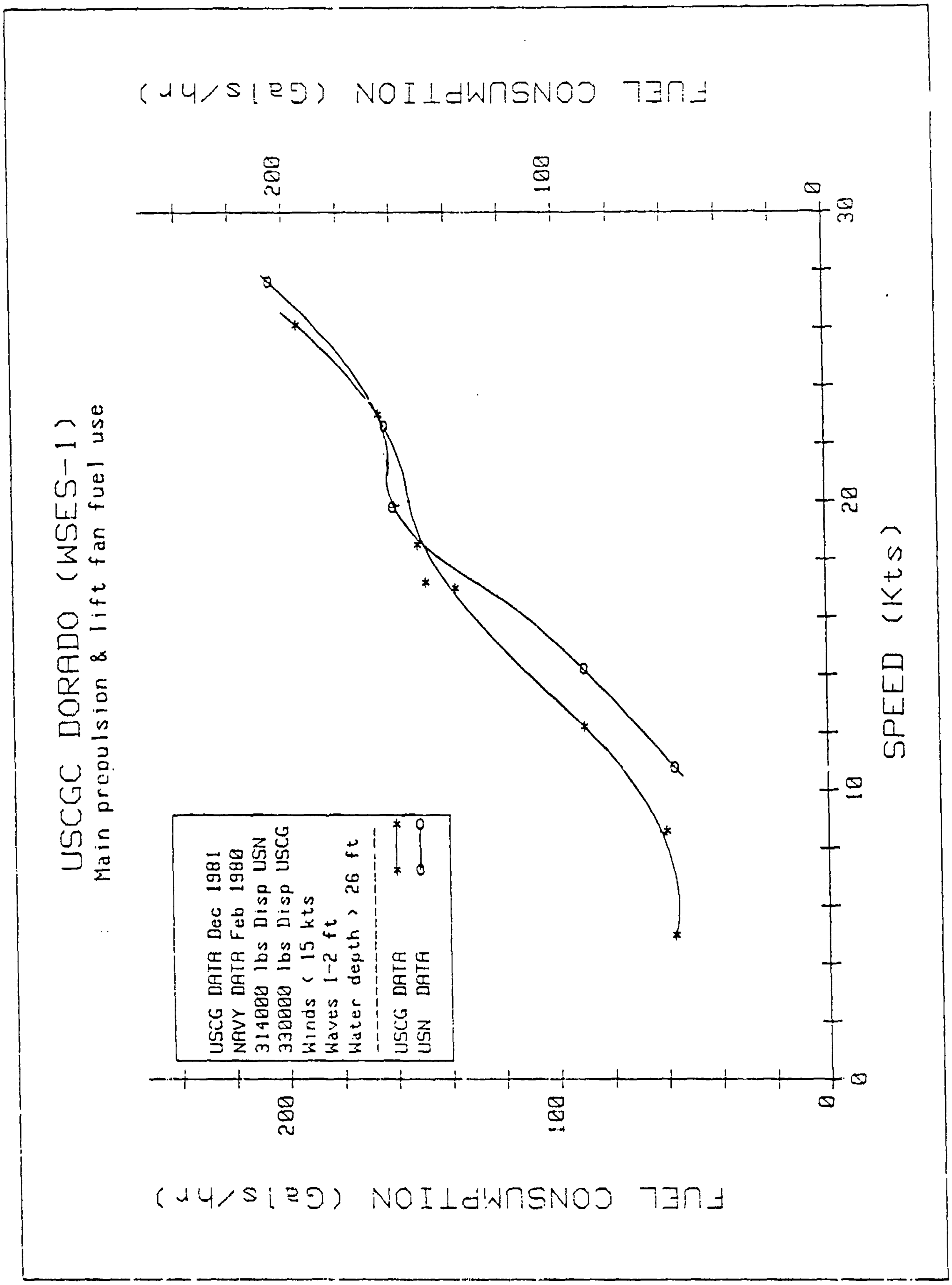


FIGURE 10
FUEL CONSUMPTION (GALS/HR) VERSUS SPEED

4.4 Towing Capability

Test 5, towing capability, was conducted. A bollard pull test was performed on 21 May 1981 at Mobile, Alabama, and an 82-foot WPB was towed on 10 November 1981 in Pensacola Bay. The DORADO was instrumented as prescribed during the 82-foot WPB tow but did not have horsepower measuring equipment installed for the bollard pull test.

The results of these tests are shown in Figures 11, 12 and 13. A maximum bollard pull of 23000 pounds was measured at 1100 ERPM off cushion. On cushion a maximum pull of 18000 pounds was measured at 900 ERPM. The DORADO was able to tow the 82-foot WPB at a speed of 11.4 knots exerting a towline pull of 7000 pounds.

No serious problems were noted affecting the ability of the SES to tow other vessels. However, the small diameter, high RPM propellers installed are optimized for high-speed performance and are not very efficient for towing. The propeller design requirements for these two conditions are quite far apart and may separate further if higher speed vessels are contemplated. It will probably be necessary to install variable or dual pitch propellers to improve performance while towing with the least effect on free route performance.

It must be noted also that the port engine was producing one-third less power than the starboard engine while towing the 82-foot WPB. For this test, bridge personnel advanced the throttles in-line visually. As a result engine imbalance was not detected and therefore not corrected during this test. Therefore, the towline pull may be slightly low as measured in these tests.

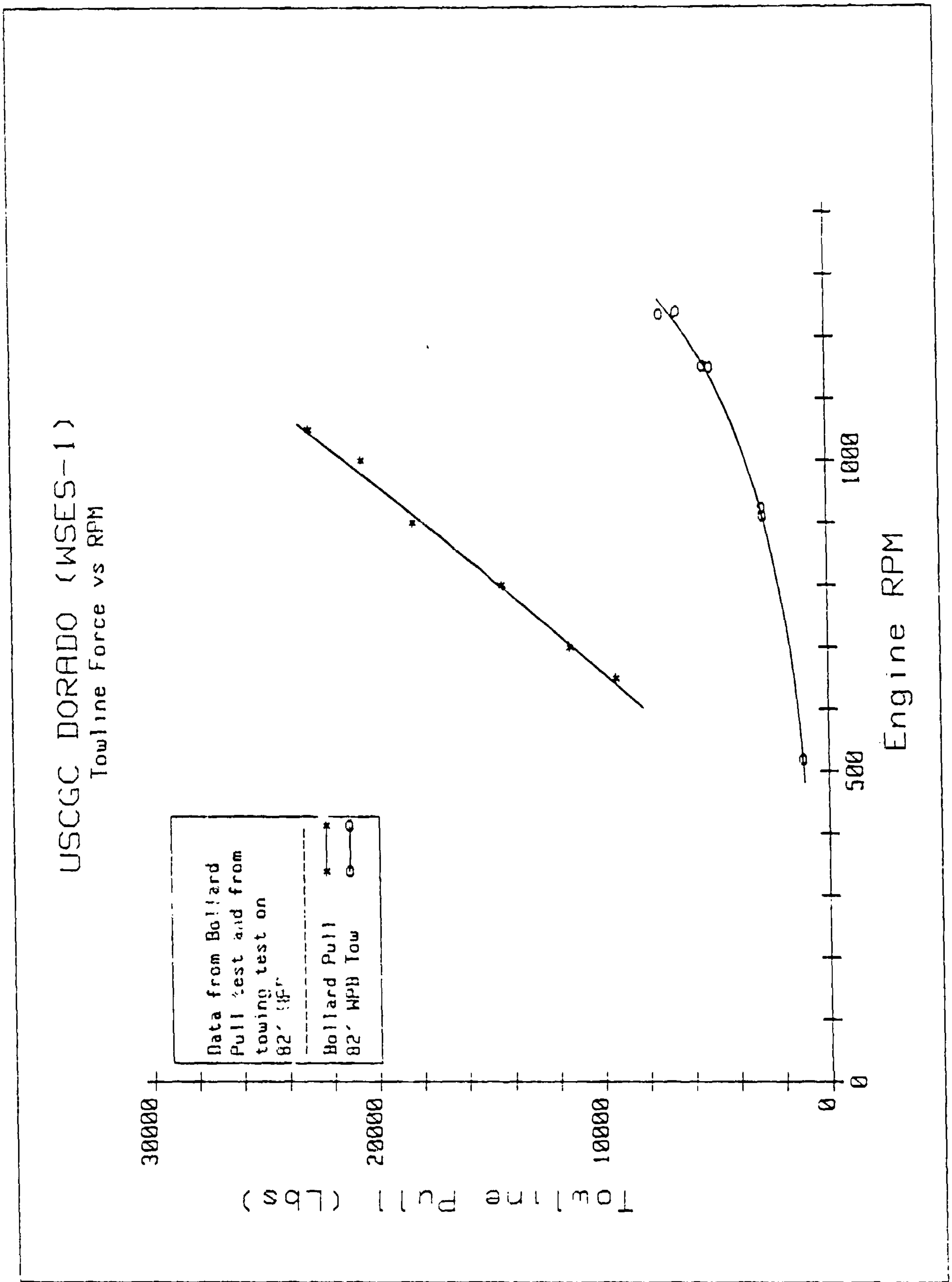


FIGURE 11
TOWLINE PULL VERSUS ENGINE RPM

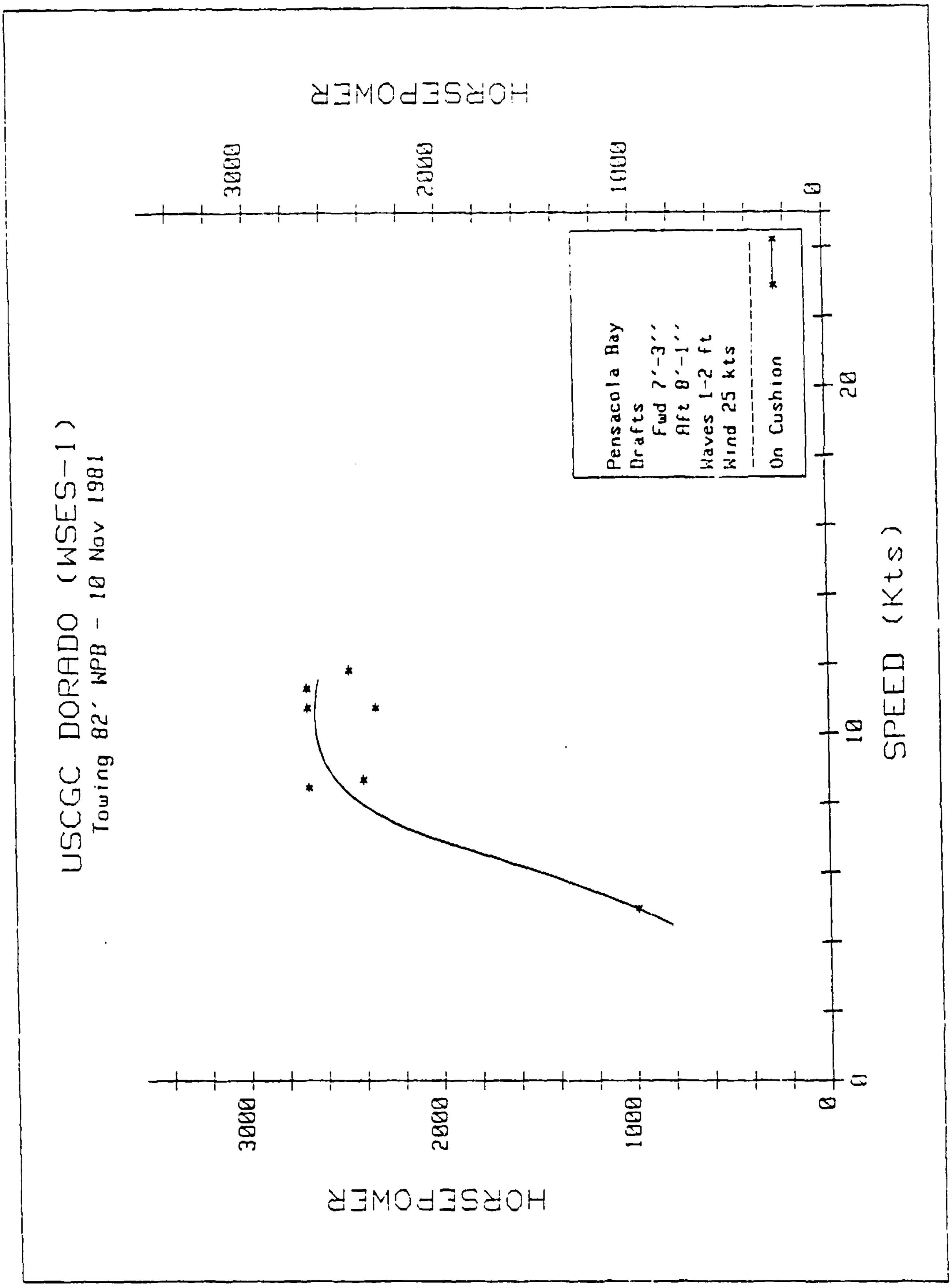


FIGURE 12
HORSEPOWER VERSUS SPEED

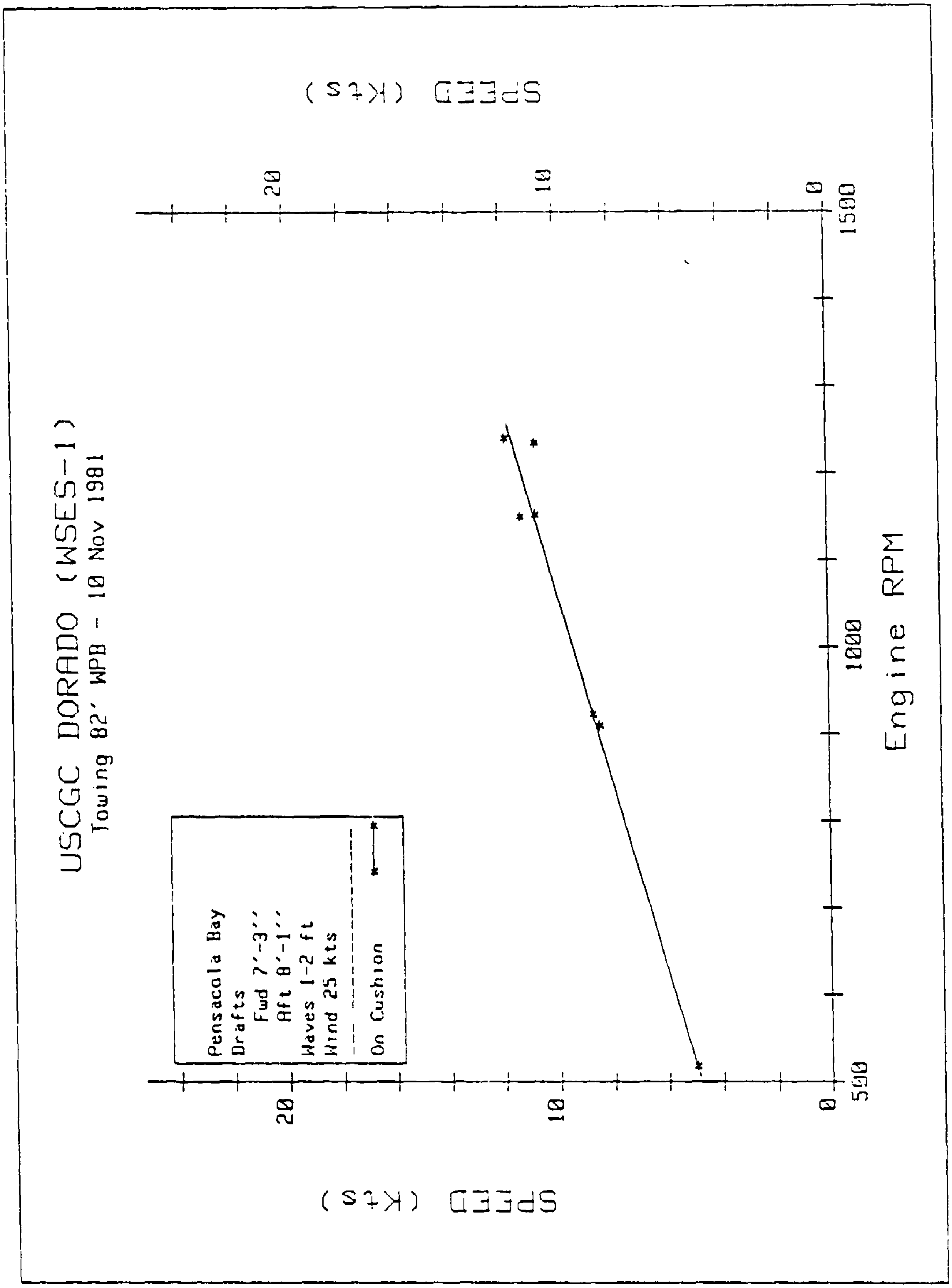


FIGURE 13
SPEED VERSUS ENGINE RPM

4.5 Spiral Maneuverability Test

Test No. 8, Maneuverability-Spiral Test, was conducted for two on-cushion speeds, 10 knots and 20 knots, and one off-cushion speed, 9 knots. An attempt was also made to conduct a spiral test with the vessel going astern. It was determined that the vessel backed into the wind and the test was terminated. However, as a result of this test it was discovered that the main engines and generators lost cooling water after only about 14 seconds of running astern. This would prevent any extended maneuvering astern at high speed.

Wind speed, wave height and current speed were within the limits specified in the General Test Plan. Figures A-1 to A-3 in Appendix A show the results of these tests. The "PLOTER" computer program in Appendix B was used to plot the data.

Test results indicate that the DORADO has stable maneuvering characteristics with no hysteresis loop apparent near zero rudder angle. The high speed, on-cushion run has the widest spread of data. This is believed to be due to the vessel turn rate having not stabilized in the time allowed. It apparently requires a significantly longer settling time to achieve a constant yaw rate at this speed.

4.6 Zigzag Maneuver and Performance in Stern Seas

Test No. 9, Maneuverability-Zigzag Maneuver, was conducted for three on-cushion speeds and two off-cushion speeds. The test also was conducted at 11 knots on-cushion with the seas from astern. The latter run satisfied the requirements of Test No. 17, Performance in Astern Seas.

The following exceptions were made to the procedures for these tests as stated in the General Test Plan. First, the low-speed maneuvering test was not performed due to the inability of the DORADO to maintain speeds of less than 6 knots. When on-cushion the vessel has very low drag which results in a clutch or idle speed of 6 knots. Also, the primary test location prevented the vessel from establishing a base course into the wind. This had a minimal effect on the test results but is evident in that it made the vessel easier to turn in one direction than the other.

Not all runs were made with course changes of 20 degrees to either side of the base course. The information from these runs is valid since the yaw rate was steady. It is the yaw rate and the rudder angle which determine the amount of overshoot.

Current speed was slightly greater than that recommended in the Test Plan. It was approximately 0.7-1.0 knots instead of the 0.5 knots called for. This caused no noticeable effect. Similarly, the water depth was much less than called for. Most of the tests were conducted in 12 feet of water on cushion. This probably caused a small change in the maneuverability of the craft. The effect does not appear to be large from the data collected.

In the stern seas performance test the wave height was approximately 2 feet instead of the 6-10 feet required. Because of the small waves the results of the test are not very meaningful. They tend to confirm the other zigzag maneuver data rather than showing a degradation of performance in stern seas.

Table 3 lists the principal factors involved in these tests. Figure 14 is a typical data plot annotated to show how the entries in the table were derived. The remaining data plots are in Appendix A. Appendix B contains the computer programs used to reduce and plot the data.

The jagged appearance of the performance in stern seas plot in Appendix A is due to the fact that the data points straddled the dead band in the yaw angle transducer. This causes a few of the data points to be off scale on the plot.

In Table 3 the time to execute, which is the time from the first execute to the second, and the period are direct measures of the ability of the vessel to rapidly change course. Overshoot yaw angle and overshoot path width are numerical measures of countermaneuvering ability and are indicative of the amount of anticipation required of a helmsman while operating in restricted waters.

Since comparable data has not yet been collected on other Coast Guard vessels, no comparisons can be made. However, there is no indication from the data collected that there exists any maneuverability problems with this vessel. It behaves similarly to a displacement vessel and is fully controllable under all speeds and configurations.

TABLE 3
ZIGZAG MANEUVER

Cushion (On/Off)	Speed (kts)	Time to Execute (Seconds)	Period (Seconds)	Overshoot Yaw Angle (Degrees)	Overshoot Path Width (Ship Length)	Comments (Left Rudder Negative)
On	8	13	100	2-8	1.35	Turn to port negative
On	20	4	30	5-9	.97	Turned much better to port
On	30	6	26	5-8	.60	Equal turning port and stbd
Off	7	10	84	3-8	.92	Turned slightly better to port
Off	10	10	54	6-10	.78	Equal turning port and stbd
On 2' stern seas	11	13	52	3-11	.62	Turned better to starboard

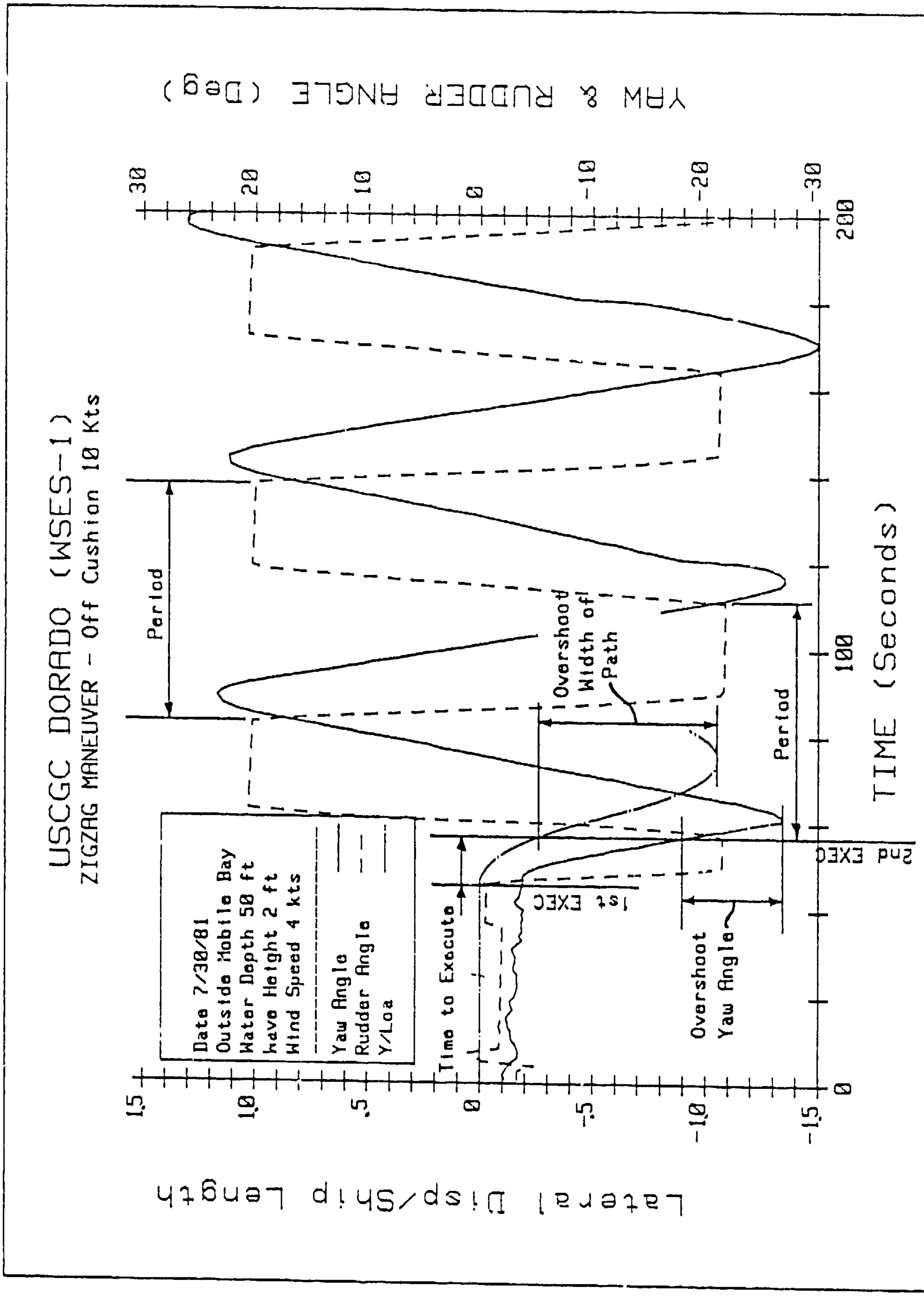


FIGURE 14
ZIGZAG MANEUVER - OFF CUSHION - 10 KTS

4.7 Time to Get Underway

The time required for the vessel to depart the dock from a dead plant condition was measured as prescribed in Test No. 10 of the General Test Plan. The times determined by this test are reasonably typical based on observations of test personnel. The elapsed times are given below.

TABLE 4
TIME TO GET UNDERWAY

Event	Elapsed Time (Minutes)
Initial notification	0
Generators started	2
Generators on line	3
Shore tie disconnected	6
Operations ready	6
Deck Department ready	6
Main engines started	9
Engineering plant ready	13
Vessel departed dock	16

This time is sufficiently short to cause little problem in responding to emergency calls.

4.3 Visibility from Deckhouse

Test 11, Visibility from the Deckhouse, was performed. The areas of clear view are shown in Figure 15. Complete availability of a 360 degree view in the X-Y plane is easily obtained by walking around the pilothouse. An arbitrary optimum viewing area has been assumed. This area extends from an angle of 15 degrees above the horizon to 20 degrees below the horizon at all horizontal angles. This area is 12600 degrees squared.

For the DORADO, the clear view area is 4636 degrees squared. This is 36.8 percent of the optimum value.

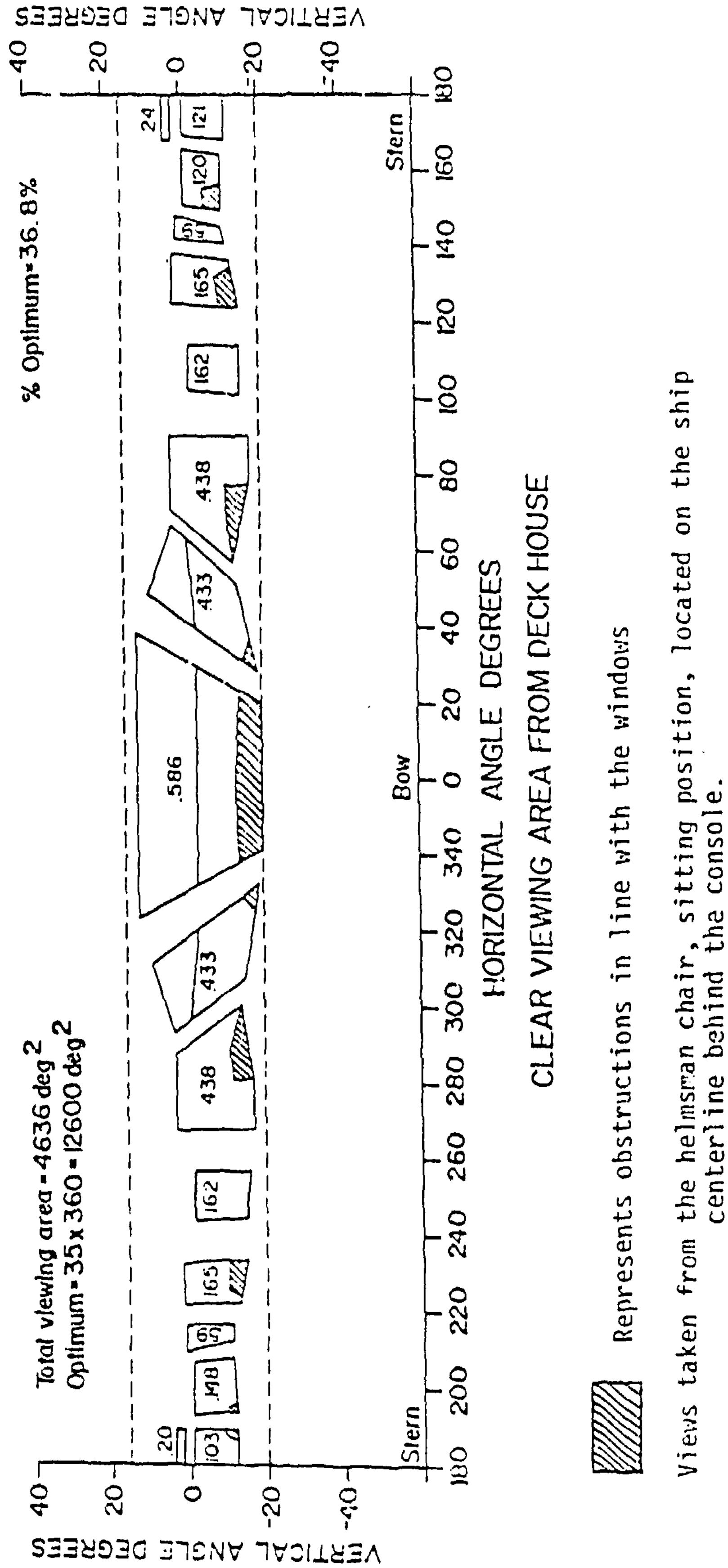


FIGURE 15
CLEAR VIEW AREA FROM DECKHOUSE

4.9 Moment to Heel and Boom Capability

Test Nos. 12 and 31 in the General Test Plan were performed. The inclining experiment was performed in less than ideal conditions. The crane used to shift the weight could not reach across the deck of the SES. As a result the SES had to be turned 180 degrees at the dock in order to shift the weights. The wind was blowing at 10-15 knots onto the pier. Therefore the moment due to the wind was added to the inclining moment in both weight locations. Calculations indicated that this added about 3 percent to the inclining moment.

Due to the extremely high GM of the SES, the GM was not adjusted for free surface in the fuel and water tanks. The tanks on the SES are all small and have small transverse dimensions so this omission will have very little effect. The tank soundings at the time of the test are reported in Appendix A, Table A-2.

A moderately successful attempt was made to measure the roll period. One 10000-pound weight was dropped about 1 foot onto one side of the deck to induce a roll. The vessel rolled only about 3 degrees and the roll damped out in one cycle. A period of about two seconds was measured but this measurement was subject to considerable error. A 2-second period equates to a radius of gyration of 13.9 feet which is a reasonable value.

A detailed description of the procedure used to measure the GM is given in Appendix D. The GM calculated is 59.4 feet which includes the effect of the beam wind. The value of KM from the curves of form is 69.2 feet, resulting in a KG of 9.8 feet. This indicates that the vertical center of gravity is located several feet below the main deck which is reasonable.

The moment to trim one inch from the curves of form is 23.2 ft-tons. If a heel angle of 6 degrees is chosen as the maximum acceptable heel angle then the maximum weight which can be lifted 5 feet off the side of the vessel is 77000 pounds at a displacement of 302500 pounds. This heel angle will result in an approximately 2-1/2 foot change in draft on the side of the vessel. This very impressive lifting capability is a result of the large GM.

Other data regarding these tests is contained in Table A-2 of Appendix A.

4.10 Motion in Waves and Susceptibility to Slamming

Tests 13, Motion in Waves, and 16, Susceptibility to Slamming, were performed on 9 November 1981 off Pensacola, Florida. Significant wave height during the tests ranged from 2 to 3 feet. This is at the low end of the acceptable test range. As a result the motions experienced were not severe. The sea state was nearly unidirectional. However, a significant component wave developed during the tests from about 100 degrees true. The primary wave direction was 140 degrees true. Water depth in the test area was 84 feet.

Motions in all six degrees of freedom were recorded together with the wave motion. Only roll, pitch and heave motions for selected runs were analyzed, however. Spectra for the runs examined are included in Appendix A together with a listing of the peak and valley ordinates of these spectra. Table A-3 in Appendix A lists the one-third and one-tenth highest motions.

The location of the motion package is shown in Figure 16. No correction has been made to the heave motion to adjust for the longitudinal distance between the location of the motion package and the center of flotation.

Three mechanical impact counters were installed in the ship's office and three in the after engineering space see (Figure 16). These were all bolted to the overhead centerline girder. These counters were read over 3-hour periods during both the on-cushion and off-cushion motion tests. Nearly all the slams occurred during the 20-minute head sea runs, however.

Most of the slamming occurred during the 8-knot run off-cushion. During the 3-hour period only two slams exceeding 1 g occurred while on cushion. Approximately 102 slams exceeding 1 g and two exceeding 2 g's occurred during the same period off cushion.

The slow-speed run in head seas was by far the roughest ride. The motion amplitudes recorded show little difference between this run and others but the coupling between the pitch and heave motions was such that a very rough ride resulted.

A continuing problem exists concerning ship motion studies of this sort. This problem results from the waves not being unidirectional. Therefore, ship motion response may not be the same in different seas even if they have the same amplitude distribution. This problem is discussed in more detail in Appendix C. Improvements are also discussed.

In general there was not a great deal of difference between the motions at the different speeds and configurations. Pitch motion at 21 knots was significantly less than at 8 knots due to the much higher frequency of encounter. Other motions were not affected much by the frequency of encounter shift with speed.

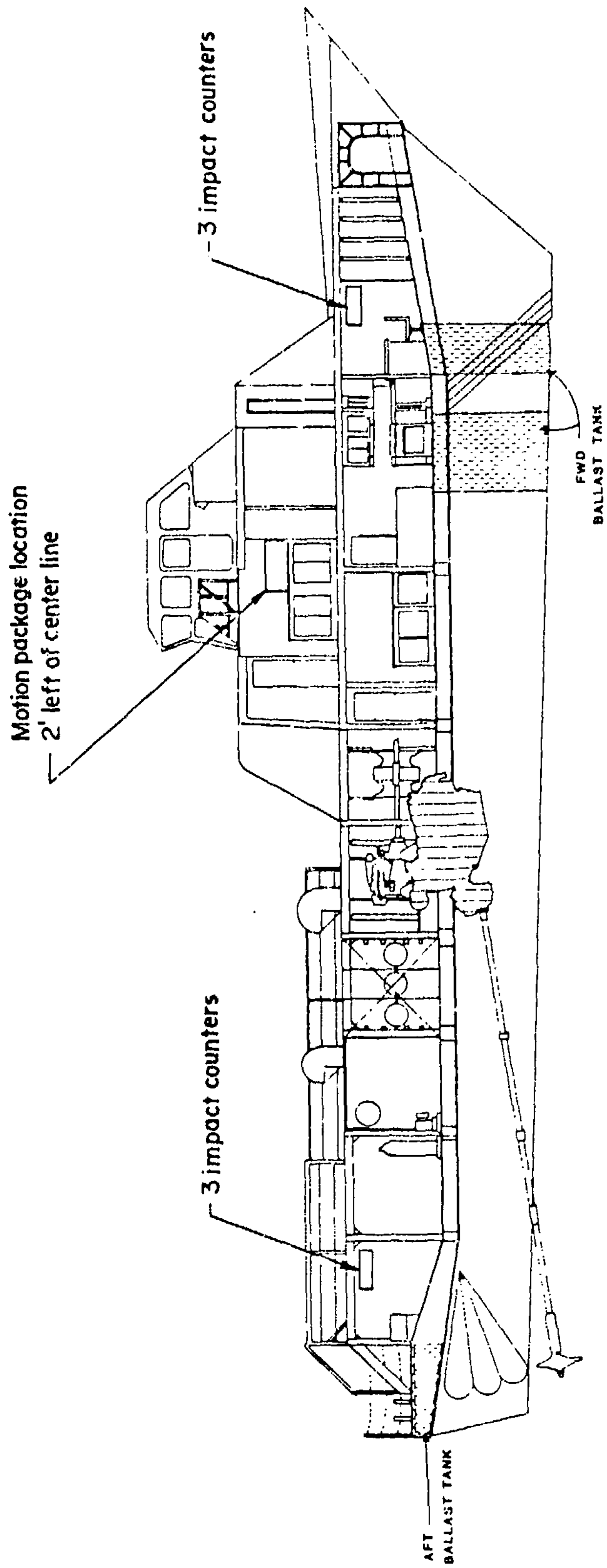


FIGURE 16
LOCATION OF MOTION PACKAGE AND IMPACT COUNTERS

4.11 Sail Area

The projected areas of the hull and deckhouse were computed as required by Test 14, Sail Area. The sail area was also computed for the vessel on cushion. The locations of the centers of area are shown in Figures 17 and 18 and are tabulated in Table 5 below. The coordinates are based on the axes shown on the figures.

TABLE 5
SAIL AREA RESULTS

	Side Area	X	Y	Fwd Area	Z
Hull on Cushion	1289	54.1	2.2	523	3.0
Hull Off Cushion	867	54.9	4.5	377	5.0
Deck House	383	66.1	14.1	276	15.3
Combined On Cushion	1672	56.8	5.0	799	7.3
Combined Off Cushion	1250	58.3	7.4	653	9.3

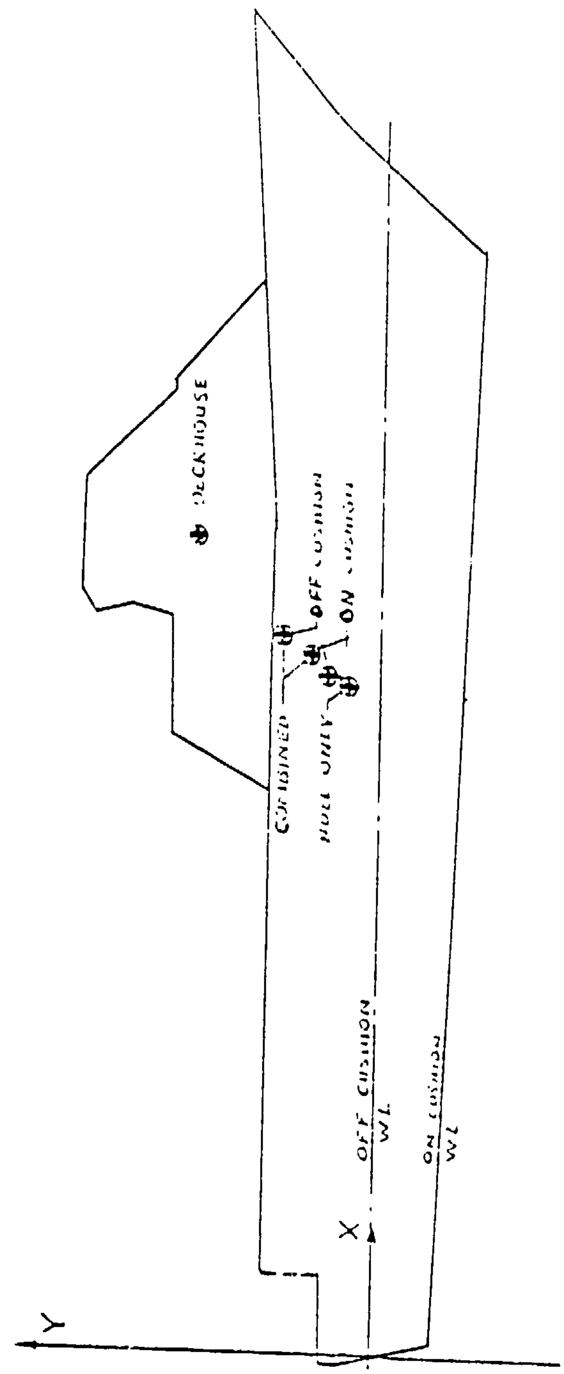


FIGURE 17
SIDE SAIL AREA CENTERS

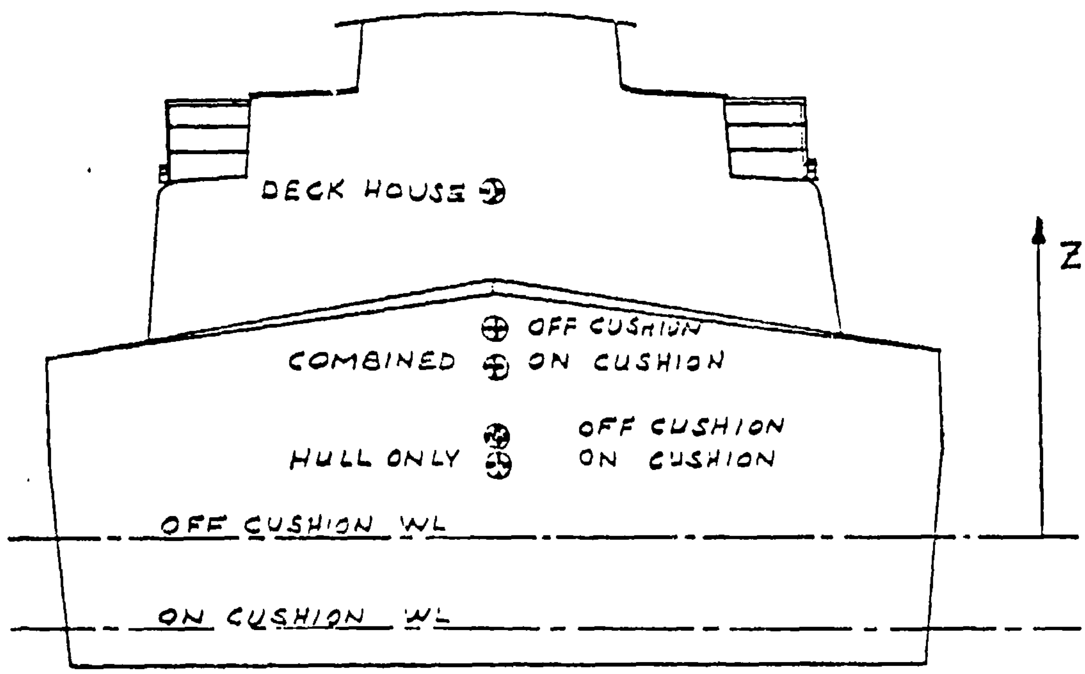


FIGURE 18
BOW SAIL AREA CENTERS

4.12 Watertight Integrity

Figure 19 shows the floodable length curve for the 110-foot SES. The cross-hatch area of this curve shows the vessel satisfies a one-compartment standard for subdivision. The area shaded with dots indicates the additional requirements for meeting a two-compartment standard. The vessel falls short of being a two-compartment vessel but only due to the combination of the machinery and cargo compartments. Any other pair of adjacent compartments could be flooded and the vessel would remain afloat provided all other compartments were intact.

A ship check indicated numerous violations of watertight integrity on the watertight boundaries. Nearly all these watertight integrity problems were due to poor maintenance, i.e., loose wire stuffing tubes. The design of an SES is very similar to that of a catamaran hull form and an SES has few additional watertight integrity problems. One that does require attention is the problem associated with the ducting for the lift cushion. On the DORADO this consisted of a passage under the first deck running the length of the vessel between the side hulls. This passage was open to the sea and connected to the interior of the vessel through the lift fans. The lift fans must be watertight to the flooded waterline or else flooding of the machinery space will result. Similar design problems will exist with any SES design but can be easily handled.

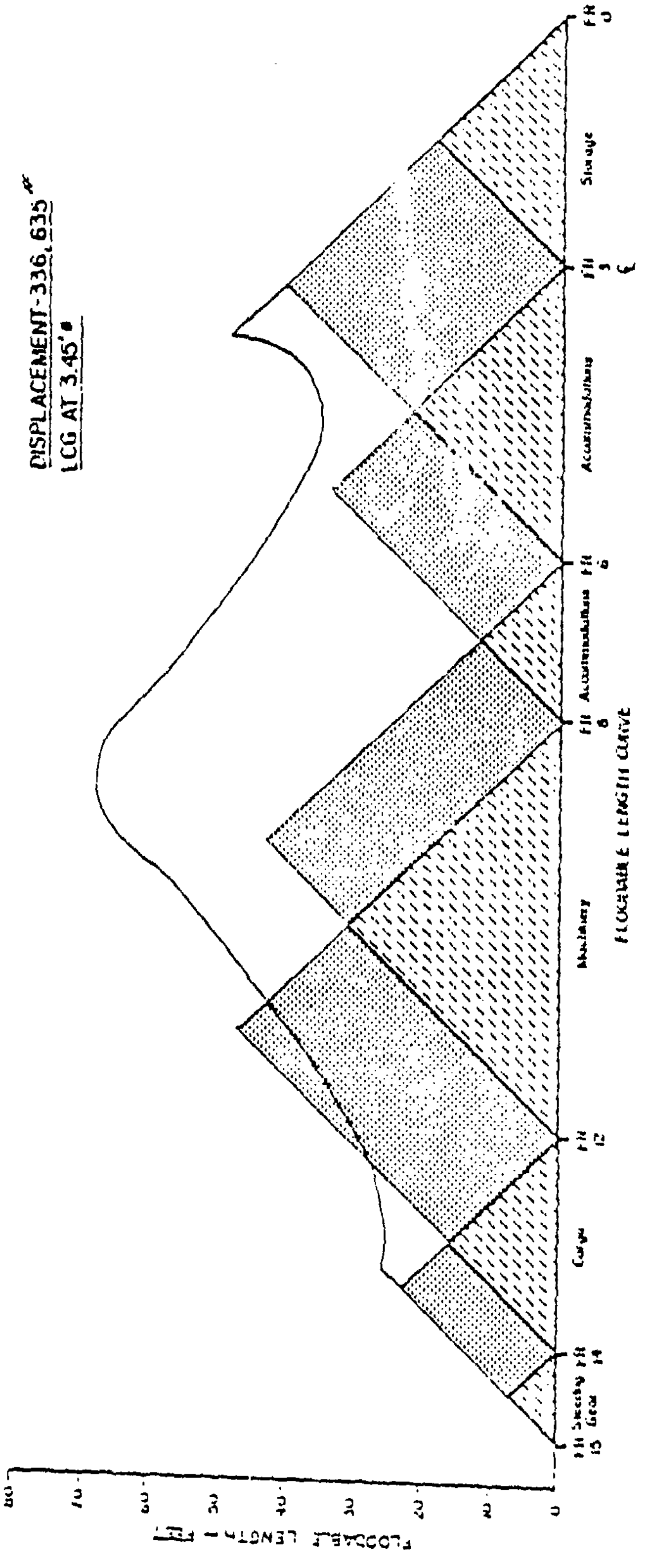


FIGURE 19
FLOODABLE LENGTH CURVE

4.13 Hull Vibrations Level

Test No. 23, Hull Vibrations Level, was conducted during the speed-power trials. No vibration measurements were made with the vessel running astern because the DORADO can operate astern for only a few minutes before losing sea suction. The procedures of Test 23 were followed. Wave height during the tests was higher than optimum. There was a 2-foot wave height instead of the desired one foot.

Six acceleration transducers were installed on the vessel in the locations designated in Figure 20. All transducers were mounted on bulkhead stiffeners near the main deck level. All locations were at hard spots which should virtually eliminate local vibrations. Plots of the vibration displacement amplitude for selected runs are included in Appendix A. Four different runs are shown in these plots. Run No. 1 was conducted at zero speed on-cushion, and Run No. 20 was conducted at zero speed off-cushion with the fans secured. Run 11 was a full-speed run on cushion and represents the peak hull vibration level. Run 16 was a 1200 rpm run off-cushion. This is maximum speed off-cushion. The pickup numbers referenced are those shown on Figure 20.

All of the results show a high level of vibration below about 2 hertz. This vibration is caused primarily by the waves. On cushion there is a pronounced peak at approximately 2.5 hertz. At zero speed this vibration is in phase along the length of the hull or, put another way, is a heaving vibration. At full speed this vibration changes to a pitching vibration. The other vibration peaks represent vibrations in the fundamental bending motion of the hull. None of the vibrations are severe and all appear to be caused by the lift fans. There is almost no vibration caused by the propellers. This is probably due to their small size and high rpm.

Although the crew complained of vibration problems on the DORADO, there appears to be no serious overall vibration of the hull. Most of the problems are probably local vibrations which must be handled individually. The lift fans seem to be the primary vibration source for vibrations of the hull as a whole. The most significant vibration is probably caused by a rhythmic venting of the cushion.

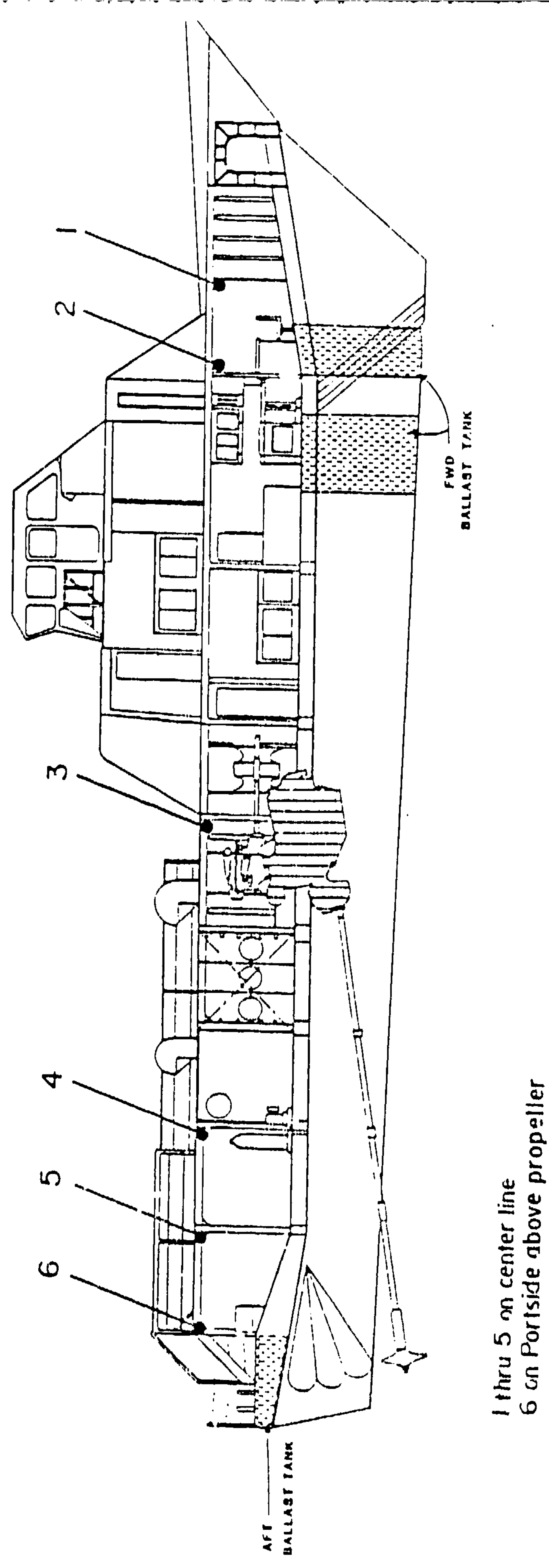


FIGURE 20
ACCELEROMETER LOCATIONS

4.14 Questionnaires

Most of the more subjective aspects of the OPEVAL were handled by having the crew fill out questionnaires. The same questionnaire was used during both test periods. The responses to the questionnaires have been compiled and are included in Appendix A. Since the number of topics covered by the questionnaires is large, no further discussion will be included here. Crew composition was less than ideal for a study of this type. This problem is one of those discussed in Appendix C. Most types of operations the Coast Guard performs were performed by the DORADO during the OPEVAL. The DORADO performed all these missions quite well and was rated by the crew to be a significant improvement over an 82-foot WPB.

4.15 Handling Pollution Gear and Anchoring

A deployment of the self-skimming barrier was observed by LCDR GOODWIN of the R&D Center (R&DC). This deployment also involved the SES towing the Coast Guard's fast deployment sled and a small Dracone barge. Two problem areas were noted. First, the SES could not get over hump speed with the sled in tow. The SES was able to maintain about 18 knots which is slightly faster than a WPB while towing the sled. Second, the SES's anchors were inadequate to hold the vessel in position with the boom deployed. In all other aspects, the SES performed as well as or better than a WPB and provided a very stable work platform.

Test 36, Anchoring, was also performed to verify other aspects of anchoring and vessel ride while at anchor. No serious problems were encountered which would prevent safe anchoring. The vessel rides well at anchor and has no tendency to override the anchor cable. There does not appear to be any danger of damaging the forward seal either when anchoring or when riding at anchor. It is apparent from calculations of the required anchor size and as a result of the barrier deployment that a significantly larger anchor is required. The anchor hoisting apparatus installed on the DORADO was inadequate to raise the anchor currently installed. An anchor capstan of adequate size and power is absolutely essential to safe anchoring.

Powering of the vessel is discussed in other sections of this report. However, as a Coast Guard vessel the SES must possess a towing capability. Variable pitch or dual pitch propellers should be considered to enhance towing performance. Propeller design will be a critical element of any high performance craft. It is nearly impossible to design an efficient fixed pitch propeller which can operate under high speed free route conditions and under high thrust low speed conditions. A well-designed dual pitch or variable pitch propeller should be a significant improvement.

4.16 Maintainability

Test 34, Maintainability, was conducted but there was insufficient data collected during the OPEVAL to determine mean time between failures and mean time to repair.

Some significant maintenance problems were noted. There were many cracks in bulkheads and stiffeners which required welding. The structure in way of the after ballast tank was particularly prone to cracks. It is clear that the structure of the SES must be increased in strength to survive the rough service Coast Guard use will impose.

Other maintenance problems resulted from local vibrations. One of these caused a very serious engineroom fire when an oil line broke spraying oil onto a turbocharger. The vibration test on the hull indicated no serious vibrations of the overall hull structure. The local vibration problems should be correctable by redesign of the structure or shock and vibration mounting of equipment. No vibration mounts were used on the DORADO.

Most of the equipment was easily accessible for maintenance. One exception is the outboard sides of the main engines. Few on board spares can be carried due to weight considerations.

4.17 Secondary Variables

The checklist from Test 35, Secondary Variables, was used during a survey of potential problem areas. Of primary importance was identification of hull or equipment items that are inadequate for Coast Guard service or which would restrict use to certain geographic locations.

About three inches of insulation was installed in the accommodation areas of the DORADO but none in the engine room or other machinery spaces. No sound deadening insulation was installed on board. In order to meet Coast Guard standards, more insulation would be required with the accompanying added weight.

There were no particular problems noted in the area of equipment vulnerability and protection from the elements. All equipment was well-protected even though venting of the cushion causes a great amount of spray on the deck.

No unique safety hazards were noted. However, the large vertical accelerations measured in previous Navy tests associated with operating this vessel in high sea states, as documented by the Naval Sea Systems Command (NAVSEASYSCOM) IN Report No. CG-D-13-81, pose a serious safety problem. Personnel are likely to be thrown around if not strapped into seats under these conditions.

Ship's plans show the location of equipment adequately.

A fixed CO_2 fire extinguishing system was installed. No sprinklers were installed. There were two fire pumps installed and pressure appeared adequate. Vital cables and watertight doors were satisfactorily located. The switch for the main fire pump was in a poor location but this could easily be corrected.

A heat pump was installed for heating and ventilation. This system appeared adequate under a heavy air conditioning load and is probably satisfactory for most heating loads as well. Heated windows were not installed in the pilot house.

A small davit with electric winch was installed to launch a 4-meter AVON rigid hull rubber boat. No significant problems were noted in boat handling using this arrangement. The boat was easily launched with a few men in seas up to 4-6 feet. Higher sea states were not observed.

Excellent navigation equipment was installed. These included two Loran-C's, a Loran-C plotter, and a VHF-FM direction finder. A small gyro compass was installed but the magnetic compass was usually used. Chart table space was adequate but not excessive. Two radars were installed.

The vessel had two VHF-FM radios and an HF radio. One VHF-FM radio was equipped to scan and also to act as a radio direction finder. Both of these features were highly useful and praised by the crew.

No cargo boom was installed.

A bilge and ballast system was installed on the SES. However, no capability was installed to pump water from a disabled craft alongside. The DORADO did carry standard Coast Guard dewatering pumps.

A total of 95 KW of generator capacity was installed. This included a 55 KW main generator and a 40 KW generator installed on the port lift fan shaft. There was no evaporator installed.

Two 8V92TI Detroit diesel engines were installed to drive the two lift fans. The port engine also is coupled to a 40 KW generator.

The actual hotel load is not known but installed capacity was more than adequate for 14-16 people. Sewage holding capability appeared to be the most critical hotel services problem.

In summary, there are few serious problems which would preclude the use of this vessel as a Coast Guard vessel. Insulation and sound deadening would have to be improved. As mentioned elsewhere in this report, the structural failures experienced require redesign and strengthening of much of the hull structure. Both of these problems will result in considerable additional hull weight and may require increased engine power to maintain performance.

APPENDIX A

DATA PLOTS AND TABLES

TABLE A-1
FUEL CONSUMPTION DATA

GENERAL DATA: 3 December 1981 - Wind SW at 10-15 knots
Seas SW at 1-2 feet

4 December 1981 - Wind SW at 10-15 knots
Seas SW at 1 foot

Water Depth (measured run) 26-40 feet
4° trim by the stern

2-3 December 1981			19-20 February 1980		
Speed	Gal/Hr	Gal/N.M.	Speed	Gal/Hr	Gal/N.M.
5.0	57	11.4	10.8	57	5.3
8.6	60	7.0	14.2	90	6.3
12.2	90	7.4	19.8	160	8.1
17.0	137	8.1	22.6	163	7.2
17.2	148	8.6	27.6	205	7.4
18.5	151	8.2			
23.0	165	7.2			
26.1	195	7.5			

Twin Screw
Gawn-Burrill Propeller
3-blade, bronze
40-inch diameter by 50.82 fixed pitch

Main Propulsion (2) - 16V149TI Detroit Diesel w/180mm injectors
(2) - 8V92TI Detroit Diesel w/9290 injectors

Draft: (Forward) 7'-10"
(Aft) 8'-6"

Displacement: 329,430 lbs

Fuel Flow Monitors by Headland products: 3000 PSI Max
3/4" Supply
1/2" Return

TABLE A-2
INCLINING EXPERIMENT

Date: 8/5/81
Location: USCG Base Mobile, Alabama
Vessel: USCGC DORADO (WSES-1)

Drafts:
Fwd Port 7'-6"
Fwd Stbd 7'-6"
Aft Port 8'-2 1/2"
Aft Stbd 8'-2"

Water Depth:	24 feet
Water Temperature:	90°F
Water Specific Gravity:	1.022
Wind Speed:	10-15 kts on beam
Air Temperature:	84°F
Barometric Pressure:	30.12

Two 10,000-pound sinkers used as inclining weights.

Liquid Loading

Tank		Tank	
1A	450 gal	3	397 gal
1B	50 gal	4A	365 gal
2A	416 gal	4B	365 gal
2B	508 gal	Pot.water	554 gal
		Lube oil	118 gal

TABLE A-3
THIRD AND TENTH HIGHEST MOTIONS - CGC DORADO

Run No.	Heading to Waves	Wave Height (meters) H 1/3	Wave Height (meters) H 1/10	Roll Angle (Deg) H 1/3	Roll Angle (Deg) H 1/10	Pitch Angle (Deg) H 1/3	Pitch Angle (Deg) H 1/10	Heave Accel.(g's) H 1/3	Heave Accel.(g's) H 1/10
21 Knots - On Cushion									
1	Stern	--	--	--	--	1.50	1.78	.115	.142
2	Head	.725	.946	--	--	.822	.981	.178	.210
3	Beam(S)	.666	.822	6.18	8.66	--	--	.174	.222
4	Beam(P)	--	--	6.47	8.54	--	--	--	--
5	Aft Qtr	--	--	5.72	6.96	2.64	5.30	.200	.228
6	Bow Qtr	--	--	5.15	6.38	2.01	3.34	.213	.247
8 Knots - Off Cushion									
7	Stern	--	--	--	--	3.01	5.12	.082	.144
8	Head	.933	1.24	--	--	3.10	3.93	.238	.289
9	Beam(S)	--	--	6.13	8.38	--	--	.196	.227
10	Beam(P)	.857	1.12	5.69	7.23	--	--	--	--
11	Aft Qtr	--	--	4.81	6.16	2.59	3.30	.188	.222
12	Bow Qtr	--	--	5.55	6.59	3.13	3.70	.220	.243

TABLE A-4

COMPILED QUESTIONNAIRE RESPONSES

QUESTIONNAIRE 15A - SUBJECTIVE SEAKEEPING CHARACTERISTICS

VESSEL NAME ______________________

YOUR NAME ______________________ DATE __________

TIME ON BOARD ______________________

This questionnaire covers some of the aspects of seakeeping which are difficult to measure. Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding seakeeping, you may include them in the Remarks section.

NUMBER OF RESPONSES SHOWN

1. Since you have been on this vessel, what were the maximum wave height and wind speed you experienced?

Wave Height		Wind Speed	
Less than 5 feet	8	Less than 20 knots	8
5-15 feet	11	20-35 knots	9
15-30 feet	1	35-60 knots	1
Greater than 30 feet	___	Greater than 60 knots	___

2. How did this vessel perform in those conditions compared to a WPB?

About the same			
Much better	9	Worse	___
Better	3	Much worse	___

3. Based on your experience, in what sea state will the vessel reach the limit of safe operation?

12, 14, 15, 20, 25, 25

Wave height 10, 10, 15, 20, 20 ______ feet

4. In what sea state does it become difficult to perform your job?

4-6, 7, 8, 8, 15, 16

Wave height 6-8, 7, 8, 8, 10, >18 ______ feet

5. What is the principal reason for this difficulty?

Motion sickness		Difficult to stand or move	14
Spray or water on deck	4		
Other (explain)	1	FOOD & WATER ON DECK	

6. How do you think the motions of this vessel in a sea compares to a WPB in terms of ability to perform your job?

Not observed	2	About the same	1
Much better	4	Worse	___
Better	7	Much worse	___

7. What motion of the vessel causes the most difficulty?

Not observed	4	Rolling	
Pitching		Vertical acceleration	8
Fore and aft acceleration	1	Side to side acceleration	
VIBRATION	1	Unpredictable accelerations	3

8. Is motion sickness a problem compared to a WPB?

Not observed	6	About the same	2
Much more of a problem		Less of a problem	3
More of a problem		Much less of a problem	4

9. Is deck wetness a problem?

Not observed			
Yes	13	No	5

10. What is the principal cause of deck wetness?

Not applicable		Spray	15
Waves washing deck	1	Vent lines	2
Other (explain)	2	CUSHION VENTING	

11. Does spray cause a visibility problem?

Not observed			
Yes	5	No	11

12. How does the visibility from this vessel in rain, sleet, or snow compare to a WPB?

Not observed	4	About the same	2
Much better	4	Worse	
Better	5	Much worse	

13. How does your ability to navigate in fog with this vessel compare to a WPB?

Not observed		About the same	
Much better	1	Worse	
Better	1	Much worse	

14. What causes fog navigation to be better or worse than a WPB?

Not applicable		Electronics installed	2
Location of lookouts	1	Plotting area available	2
Other (explain)			

15. What wave height limits the maximum speed of the vessel, i.e., when do you have to slow down to operate the vessel safely?

Not observed

Wave height 6, 6-8, 6-8, 5-15, 8, 10 ______ feet
6-8, 8, 8-12, >18

16. What is the principal reason for slowing down?

Not observed	___	Vessel motions	5
Slamming	10	Motion sickness	___
Water on deck	___	Spray	1
Other (explain)	1	VERTICAL ACCELERATIONS	

17. What direction to the waves provides the best ride?

Head seas	1	Bow seas	2
Beam seas	___	Quartering seas	3
Stern seas	9		

18. What direction to the waves provides the worse ride?

Head seas	6	Bow seas	3
Beam seas	2	Quartering seas	2
Stern seas	1		

19. At what headings, if any, do you feel it would be unsafe to operate the vessel in the maximum sea state you have seen while on the vessel? Check all that apply.

Head seas	5	Bow seas	6
Beam seas	4	Quartering seas	2
Stern seas	2	All headings safe	5

20. In the maximum sea state you experienced, could the vessel be kept on course at all headings?

Not observed			
Yes	11	No	2

21. If no, what headings prevent maintaining course?

Not applicable	___	Head seas	
Bow seas	___	Beam seas	2
Quartering seas	1	Stern seas	1

22. What procedure do you feel is best for improving the ship's ride in high seas?

Not observed	___	Slow down on present course	7
Change course	1	Heave to	1
Change operating condition (come off cushion, etc.)	3	Other (explain)	1
Best operating condition	___	USE PARTIAL CUSHION	

23. How does the susceptibility of this vessel to icing compare to a WPB?

Not observed	___	About the same	1
Much better	___	Worse	___
Better	___	Much worse	___

24. Is this vessel more susceptible to damage due to deadheads in the water than WPB?

Not observed		About the same	2
More susceptible	8	Less susceptible	1

25. Remarks. Include comments on any aspects of seakeeping not covered in the questions above which you feel are important.

MUCH MORE STABLE THAN WPB. MAKES WORKING ALONGSIDE ANOTHER VESSEL EASIER. ALLOWS CREW TO GET GOOD NIGHTS SLEEP

QUESTIONNAIRE 19A - HABITABILITY

VESSEL NAME ______________________________

YOUR NAME ______________________________ DATE ____________

TIME ON BOARD ______________________________

This questionnaire covers some of the aspects of habitability. That is, how comfortable is it to work and rest aboard the vessel. Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding habitability, you may include them in the Remarks section.

1. Overall, how do you feel the habitability on this vessel compares to a WPB?

Much better	14	Worse	___
Better	___	Much worse	___
About the same	___		

2. How do you rate the berthing compartments on this vessel?

Excellent	16	Poor	___
Good	4	Terrible	___
Only fair	___		

3. How do you rate the messing facilities?

Excellent	15	Poor	___
Good	4	Terrible	___
Only fair	1		

4. How do you rate the sanitary (heads, showers) facilities?

Excellent	4	Poor	4
Good	8	Terrible	2
Only fair	2		

5. What was the noise level like where you worked and slept?

Where You Worked		Where You Slept	
Not observed		Not observed	
Quiet	4	Quiet	3
Mildly noisy	6	Mildly noisy	8
Very noisy	6	Very noisy	6
Deafening	3	Deafening	2

6. Did the noise level affect your ability to perform your job?

Not observed			
Yes	5	No	13

7. Did the noise level affect your ability to get a good night's sleep?

Not observed
Yes 5 No 15

8. How did the motion of the vessel affect your ability to get a good night's sleep?

Prevented sleep ___ Made it difficult to sleep 2
Had little effect on sleep 13 Not observed ___

9. How does the motion of this vessel compare to a WPB in its effect on your ability to sleep?

Much better 4 Worse ___
Better 5 Much worse ___
About the same 2

10. What is the temperature in the berthing and messing areas like?

Not observed ___ Just right 10
Too hot ___ Too cold 1

11. Did temperature in the berthing compartment affect your ability to get a good night's sleep?

Not observed ___
Yes ___ No 10

12. What was the vibration level like where you worked and slept?

Where You Worked		Where You Slept	
Not observed		Not observed	
No vibrations	___	No vibrations	___
Moderate vibrations	11	Moderate vibrations	9
High vibrations	9	High vibrations	7

13. Did the vibration level affect your ability to perform your job?

Not observed
Yes 4 No 15

14. If yes, what was the principal way it affected your ability to do your job?

EVERYTHING HAS TO BE TIED DOWN

15. Did the vibration level affect your ability to get a good night's sleep?

Not observed
Yes 3 No 15

16. How does the vibration level on this vessel compare to a WPS?

Not observed	___	About the same	1
Much higher vibrations	8	Lower vibrations	___
Higher vibrations	3	Much lower vibrations	1

17. Remarks. Comment on any factors concerning habitability which were not covered above.

ENGINEROOM MUCH TOO NOISY. DOUBLE EAR PROTECTION REQUIRE

VIBRATIONS MAKE IT DIFFICULT TO WRITE

FOOD PREPARATION IS MORE DIFFICULT THAN ON A WPB

~~ON~~ AFTER DECK TOO NOISY TO COMMUNICATE

QUESTIONNAIRE 20A - OPERATIONS EQUIPMENT ARRANGEMENT

VESSEL NAME ______________________

YOUR NAME ______________________ DATE ____________

TIME ON BOARD ______________________

This questionnaire covers some aspects of the arrangement of equipment used by the operations personnel. Answer the questions you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding operations equipment arrangement on this vessel, you may include them in the Remarks section.

1. Compared to a WPB, what equipment was easier or more convenient to use and what was less convenient to use?

Easier or More Convenient	More Difficult or Less Convenient
GALLEY & REEFER SPACES	BOOM FOR SMALL BOAT
BRIDGE	FIRE FIGHTING GEAR
NOVA SCAN, VHF RADIO	RADAR
	FATHOMETER

2. Did difficulty in using some navigation equipment cause significant problems affecting the safe operation of the vessel?

Not observed
Yes 1 No 10

3. If yes, which equipment caused the problem and why?

CAN'T PLOT ON RADAR

4. Did some equipment peculiar to this vessel make it significantly easier to operate the vessel safely?

Not observed
Yes 4 No 4

5. If yes, what equipment?

HELM, NAV COMPUTER, RADARS, LORAN-C, PLOTTER

6. How would you rate the ease of conducting night operations with this vessel compared to a WPB?

Not observed ___ About the same 4
Much easier 2 More difficult ___
Easier 5 Much more difficult ___

7. What principal aspects of the equipment or equipment arrangement made it easier or more difficult?

EQUIPMENT LAYOUT MORE ROOM TO OPERATE

8. Were there unique safety hazards associated with using the operations equipment on this vessel which did not exist on a WPB? If so, list them.

Not observed	___	No unique hazards	5
Unique hazards	SLIPPERY DECKS		

9. Did the motion of the vessel cause significant problems for you in equipment operation?

Not observed			
Yes	5	No	9

10. Did vibrations cause problems with the equipment?

Not observed			
Yes	5	No	9

11. Compared to a WPB, what was the noise level in the pilothouse like?

Not observed		About the same	2
Much noisier	1	Somewhat quieter	4
Somewhat noisier	5	Much quieter	___

12. What was the overall effect of noise, vibration, and ship motion on your ability to do your job?

Not observed	___	Caused little difficulty	9
Made it extremely difficult		Had no effect	5
Made it difficult	3		

13. Did you find this vessel more fatiguing than a WPB?

Yes	1	No	11

Less fatiguing?

Yes	7	No	1

14. Was there adequate protection from the elements to permit you to operate the vessel effectively?

Not observed			
Yes	12	No	2

15. Did exhaust gas from the stacks cause any problems with vessel operation?

Not observed			
Yes	4	No	11

16. Do you think this vessel could be operated without damage in waters containing floating ice?

Not observed

Yes __I__ No __12__

17. Remarks. Comment on any other aspect of operations equipment arrangement which you choose.

QUESTIONNAIRE 21A - ENGINEERING EQUIPMENT ARRANGEMENT

VESSEL NAME ______________________________

YOUR NAME ______________________ DATE ____________

TIME ON BOARD ______________________

This questionnaire covers some aspects of the arrangement of equipment used by the engineering personnel. Answer the questions you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding engineering equipment arrangement on this vessel, you may include them in the Remarks section.

1. Compared to a WPB, what equipment was easier or more convenient to run and what was less convenient to run?

Easier or More Convenient	More Difficult or Less Convenient
SEWAGE	FUELING
ALARMS	LOW OVERHEAD
	HEAT & NOISE

2. Did difficulty in operating any of the machinery cause significant problems affecting the safe operation of the vessel?

   Not observed
   Yes _1_ No _5_

3. If yes, which equipment caused the problem?

   ____

4. Did some machinery peculiar to this vessel make it significantly easier to operate the vessel safely?

   Not observed
   Yes _1_ No _5_

5. If yes, what equipment?

   ____

6. Compared to a WPB, were the main engines easier to work on?

   Not observed
   Yes _4_ No _1_

More difficult to work?

Not observed			
Yes	1	No	4

7. How would you rate the ease of maintenance of equipment in the engine rooms compared to a WPB?

Not observed		About the same	2
Much easier to maintain		Harder to maintain	3
Easier to maintain		Much harder to maintain	1

8. How would you rate the ease of maintenance of all equipment outside the engine rooms compared to a WPB?

Not observed		About the same	3
Much easier to maintain		Harder to maintain	2
Easier to maintain		Much harder to maintain	1

9. Which equipment cause the most maintenance problems and why?

VIBRATION OF LINES, SEWAGE EQUIPMENT

10. Were there unique safety hazards associated with running the engineering plant on this vessel which did not exist on a WPB? If so, list them.

Not observed		No unique hazards	

Unique hazards CANT VIEW OUTBOARD SIDE OF MDE'S, GEAR BOX GAUGES NEED TO BE REMOTE, POOR VENTILATION WHILE FUELING

11. Did the motion of the vessel cause significant problems for you in equipment operation?

Not observed			
Yes	2	No	7

12. Did vibrations cause problems with the equipment?

Not observed			
Yes	9	No	4

13. What equipment was most affected by vibrations?

PIPES, NUTS & BOLTS

14. Compared to a WPB, what was the noise level in the engine room like?

Not observed		About the same	1
Much noisier	8	Somewhat quieter	
Somewhat noisier		Much quieter	

15. What was the overall effect of noise, vibration, and ship motion on your ability to do your job?

Not observed		Caused little difficulty	5
Made it extremely difficult	1	Had no effect	1
Made it difficult	6		

16. Did you find this vessel more fatiguing than a WPB?

Yes 3 No 6

Less fatiguing?

Yes 4 No 3

17. Did you experience any problems with equipment failing due to hot weather?

Not observed ___
Yes ___ No 9

18. If so, what equipment?

____

19. Did any equipment fail due to cold weather?

Not observed ___
Yes ___ No 8

20. If so, what equipment?

____

21. Remarks. Comment on any other aspect of engineering equipment arrangement or operation which you choose. Comment on superfluous equipment or needed equipment which was not on board.

QUESTIONNAIRE 22A - DECK EQUIPMENT ARRANGEMENT

VESSEL NAME ____________________

YOUR NAME ____________________ DATE ____________

TIME ON BOARD ____________________

This questionnaire covers some aspects of the arrangement of equipment used by the deck department. Answer the questions you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding deck equipment on this vessel, you may include them in the Remarks section.

1. Compared to a WPB, what equipment was easier or more convenient to use and what was less convenient to use?

Easier or More Convenient	More Difficult or Less Convenient
TOW GEAR SETUP	ANCHOR HANDLING
BOARDING FROM BOAT	SMALL BOAT DAVIT
SMALL BOAT	TOW BITT

2. Did difficulty in operating any of the equipment cause significant problems affecting the safe operation of the vessel?

Not observed ___
Yes ___ No 12

3. If yes, which equipment caused the problem?

____

4. Did some equipment peculiar to this vessel make it significantly easier to conduct operations safely?

Not observed
Yes 2 No 6

5. If yes, what equipment?

BOARDING FROM AFTER DECK GOOD STABILITY

6. Compared to a WPB, was the deck equipment easier to maintain?

Not observed
Yes 7 No 1

More difficult to maintain?

Not observed			
Yes	1	No	6

7. How would you rate the ease of maintenance of the hull (painting, etc.) compared to a WPB?

Not observed		About the same	4
Much easier to maintain	1	Harder to maintain	
Easier to maintain	2	Much harder to maintain .	

8. What equipment or structure caused the most maintenance problems?

______________________ ______________________

9. Were there unique safety hazards associated with deck operations on this vessel which do not exist on a WPB? If so, list them.

Not observed		No unique hazards	7
Unique hazards	HULL CRACKS DUE TO POUNDING		

10. Did the motion of the vessel cause significant problems for you in equipment operation?

Not observed			
Yes		No	13

11. Did vibrations cause problems with the equipment?

Not observed			
Yes	2	No	11

12. What equipment was most affected by vibrations?

WELDS, HULL STRUCTURE

13. Compared to a WPB, what was the noise level on deck like?

Not observed		About the same	
Much noisier	9	Somewhat quieter	
Somewhat noisier	3	Much quieter	

14. What was the overall effect of noise, vibration, and ship motion on your ability to do your job?

Not observed		Caused little difficulty	7
Made it extremely difficult		Had no effect	4
Made it difficult	2		

15. Did you find this vessel more fatiguing than a WPB?

Yes	1	No	12

Less fatiguing?

Yes 2 No 1

16. Did you experience any problems with equipment failing due to hot weather?

Not obs ·· ·
Yes ___ No 12

17. If so, what equipment?

18. Did any equipment fail due to cold weather?

Not observed
Yes 1 No 8

19. If so, what equipment?

20. Remarks. Comment on any other aspect of deck equipment arrangement or operation which you choose. Comment on superfluous equipment or needed equipment which was not on board.

QUESTIONNAIRE 27A - OBSERVED MISSION SUPPORT CAPABILITY

VESSEL NAME ______________________________

YOUR NAME ______________________________ DATE ______________

TIME ON BOARD ______________________________

This questionnaire is intended for engineering personnel who are a part of the test team. It will not be completed by the crew. Various issues are included which affect the ability of the vessel to conduct its mission but which do not fit well into other categories. A survey must be made of the vessel before completing this questionnaire in order to determine the capabilities of the vessel. In general, the test vessel will not have installed capability in the areas of interest or the installed capability may be minimal. You must, therefore, look for problem areas which would prevent installation or diminish the capability if installed. Advantages which the test craft type possesses over other vessel types should be noted. Of greatest interest are those characteristics of the test vessel type. Characteristics peculiar to the specific test vessel should be noted but kept separate from type characteristics.

COMPLETED BY R&DC PERSONNEL

1. Could a water washdown system be installed to wash the entire main deck and deckhouse?

   Yes ✓ No ___

2. Would any equipment of significant importance to the operation of the craft need to be secured to operate the water washdown system if installed? List.

   NONE

3. Is there any reason why a firefighting system similar to that installed on CG cutters could not be installed on this vessel.

   Yes ___ No ✓

4. If yes, what is the reason?

   ____

5. Is this craft, due to its design or materials of construction, prevented from getting as close to another burning ship or structure as a conventional steel-hulled vessel could get?

   Yes ✓ No ___

6. Could the vessel get close enough to a major fire to use a fire monitor if one was installed?

   Yes ✓ No ___
   Probably ___

7. How would you rate the damage stability of this vessel type compared to a WPB?

Much better	___	Worse	✓
Better	___	Much worse	___
About the same	___		

8. Is there anything in the design of the vessel that would prevent installing an adequate dewatering system on board?

Yes ___ No ✓

9. If yes, explain.

____

10. Can this vessel dewater another vessel using all the methods conventionally used?

Yes ✓ No ___

11. If problems exist in dewatering another vessel, explain them.

____

12. How difficult would it be to load cargo onto this vessel compared to a WPB?

Much easier	___	More difficult	___
Easier	✓	Much more difficult	___
About the same	___		

13. What is the potential cargo capacity of this vessel compared to a WPB?

Much greater	___	Less	___
Greater	✓	Much less	___
About the same	___		

14. What characteristics of this vessel make it easier or more difficult to load cargo?

OPEN DECK & CARGO SPACE AT DECK LEVEL

15. Could oceanographic and similar work be conducted over the side of this vesse

Yes ✓ No ___

16. Are these potential hazards in conducting such operations not found on conventional cutters?

Yes ___ No ✓

17. If yes, what are they?

____

18. Does the freeboard on this craft make working over the side easier or more difficult than on a WPB?

Much easier	___	More difficult	___
Easier	✓	Much more difficult	___
About the same	___		

19. Could underway replenishment gear be installed on this vessel type if the vessel was the size of a large cutter.

Yes ✓ No ___

20. What factors peculiar to the vessel type would affect such an installation?

NONE

21. Could a flight deck be installed on this vessel type?

Yes ✓ No ___

22. If yes, approximately what length vessel would be required?

200 FT

23. If no, what aspects of the vessel configuration would prevent it?

___

24. Are there any unique hazards which would prevent refueling a helo on deck?

Yes ___ No ✓

In the air?

Yes ___ No ✓

25. If yes, list the hazards.

___

26. Do appendages or other aspects of this vessel type's configuration make it especially dangerous to put swimmers in the water?

Yes ✓ No ___

27. If yes, what are these aspects?

YES ONLY IF ON CUSHION

28. Is there any reason why conventional shore tie connections can not be installed on this vessel?

Yes ___ No ✓

29. If yes, list the reasons.

____

30. Could a sonar be installed in the hull of this vessel?

Yes ___ No ___
Probably ✓

31. Could the sonar be made as effective as a sonar on a conventional hull?

Yes ___ No ___
Probably ✓

32. Could a towed sonar system be installed?

Yes ✓ No ___
Probably ___

33. Are special sensors required to detect wave height or craft elevation above the surface?

Yes ___ No ✓

34. Can the vessel be operated safely should such sensors fail?

Yes ___ No ___
Probably ___

35. Could an underwater communication system to a submersible be installed for use with the vessel DIW.

Yes ✓ No ___

36. If no, why not?

____

37. Could a small one or two-man submersible be lifted from the water and carried on deck?

Yes ✓ No ___

38. Remarks. Comment on any other points regarding the above questions which you wish. ALUMINUM HULL AND RUBBER SEALS WILL FORCE VESSEL TO STAND OFF FARTHER FROM FIRES

QUESTIONNAIRE 28A - SUBJECTIVE MISSION SUPPORT CAPABILITY

VESSEL NAME ______________________

YOUR NAME ______________________ DATE ____________

TIME ON BOARD ______________________

This questionnaire covers some aspects of the vessel's ability to perform Coast Guard missions which other questionnaires do not. Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make concerning the application of this vessel to CG missions, you may include them in the Remarks section.

1. Do you feel an up-to-date plot of the vessel's position can be maintained or does the speed of the vessel make it difficult to keep such a plot?

   Not observed
   Plot can be maintained very easily 11
   Plot can be maintained with little difficulty 4
   Marginally able to maintain plot ___
   Plot cannot be kept up to date ___

2. Does the navigation equipment installed provide the information you need to navigate in a timely manner?

   Not observed
   Yes 13 No ___

3. Do you need more information or information more often?

   Not observed
   Yes ___ No 10

4. Are there other problems with navigation due to the design of this type vessel

   Not observed
   Yes I No 9

5. If yes, what problems?

   FATHOMETER NEEDED ON CUSHION

6. Does the configuration of the vessel cause problems with the installation and use of standard CG communication equipment.

   Not observed
   Yes ___ No 12

7. If yes, list the problems.

____

8. How would you rate the freeboard of this vessel when boarding another vessel alongside?

Not observed ___ Just right 10
Much too high 1 Too low ___
Too high 1 Much too low ___

9. Were there hull appendages or other aspects of the vessel's design that made it difficult or impossible to come alongside another vessel?

Not observed ___
Yes ___ No 13

10. If so, what were they?

____

11. Were there hazards unique to this vessel type which made coming alongside in a small boat difficult?

Not observed
Yes 2 No 13

12. If yes, what hazards exist?

SES STABLE WHILE SMALL BOAT MOVES WITH WAVES

13. How would you rate the difficulty of boarding this vessel from a small boat compared to boarding a WPB?

Not observed About the same
Much easier 4 More difficult 1
Easier 6 Much more difficult ___

14. Do you feel a larger vessel of this type could be outfitted with underway replenishment equipment and replenished underway safely?

Not observed
Yes 14 No ___

15. If no, what are the main problem areas?

____

16. Do you think it is safe to put a swimmer in the water from this vessel?

Not observed
Yes 16 No ___

17. Do hull appendages or other aspects of this vessel type make putting a man in the water dangerous?

Not observed			
Yes		No	15

18. Do you foresee significant problems in recovering a swimmer from the water with this vessel?

Not observed			
Yes	1	No	17

19. Compared to a WPB, how difficult is it to get an injured person from the water onto the vessel?

Not observed		About the same	1
Much easier	3	More difficult	2
Easier	3	Much more difficult	

20. If the vessel had a flight deck installed, do you think you would have significant problems launching and recovering a helo?

Not observed			
Yes	1	No	16

21. How large a crew would be required to launch and recover a helo?

3-15

22. How would you rate the ease of mooring and unmooring the vessel compared to a WPB?

Not observed		About the same	6
Much easier	4	More difficult	1
Easier	1	Much more difficult	

23. What is the principal factor which made it easier or more difficult to moor?

BETTER RUDDER RESPONSE   BIGGER SIZE

24. Did you have significant difficulty loading stores and cargo on the vessel?

Not observed			
Yes	1	No	13

25. Was it easier or more difficult than loading stores and cargo on a WPB?

Not observed		About the same	6
Much easier	2	More difficult	1
Easier	2	Much more difficult	

26. Did the vessel deploy any pollution cleanup equipment while you were on board?

Yes	2	No	14

27. Which major pieces of equipment were deployed? ______

SLED & BOOM

______

28. How would you rate the ease of deploying pollution equipment from this vessel as compared to a WPB?

Not observed		About the same	3
Much easier	2	More difficult	
Easier	1	Much more difficult	

29. Overall, do you think this vessel would be an effective means of transporting pollution equipment to the scene of an oil spill?

Not observed			
Yes	11	No	

30. Providing that proper lifting equipment were installed do you think this vessel could launch and recover a small (one or two man) submersible?

Yes	13	No	1

31. If no, why not?

______

32. Remarks. Include any other comments on the usefulness of this vessel type on CG missions.

QUESTIONNAIRE 30A - BOAT LAUNCHING CAPABILITY

VESSEL NAME ______________________

YOUR NAME ______________________ DATE ____________

TIME ON BOARD ______________________

This questionnaire covers some of the aspects of boat launching which are difficult to measure. Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding the ability to launch a small boat from the vessel, you may include them in the Remarks section.

1. What is the maximum wave height in which you have seen the boat launched and recovered?

Not observed	___	10-15 feet	___
Less than 5 feet	10	15-20 feet	___
5-10 feet	4	Greater than 20 feet	___

2. Compared to a WPB, how easy was it to launch and recover the boat from this vessel?

Not observed	___	About the same	2
Much easier	3	Somewhat more difficult	2
Somewhat easier	4	Much more difficult	___

3. Were there significant safety hazards involved in launching a boat from this vessel?

Yes	4	No	10
Not observed	___		

4. List the safety hazards which were most significant.

GAP WITH SAFETY CHAINS DOWN

5. What effect did the freeboard on this vessel have on launching and recovery operations compared to a WPB?

Not observed	___	No difference	3
Made job easier	2	Made job more difficult	4

6. Was the boat-handling equipment (davits, lines, etc.) better or worse than a WPB?

Not observed		About the same	5
Much better	1	Worse	4
Better	3	Much worse	

7. If you could have modified the boat-handling equipment and arrangement any wa you wished could it be made better than the current arrangement on a WPB?

Not observed		Could be made better	6
Could not be made as good		Could be made much better	3
Could be made as good	3		

8. From where on the vessel do you feel it is best to launch a small boat?
STERN OR SIDE

9. What is the maximum wave height that you feel it is safe to launch and recove the small boat in from this vessel?

Less than 5 feet	6	15-20 feet	
5-10 feet	7	Greater than 20 feet	
10-15 feet	1	Wave height ______ feet	

10. Remarks. Comment on any other factors affecting boat launching which you choose.

QUESTIONNAIRE 32A - SURVIVABILITY

VESSEL NAME ______________________

YOUR NAME ______________ ______________ DATE ______________

TIME ON BOARD ______________________

This questionnaire cover[illegible] some of the aspects of survivability as they apply to this vessel. Answer th[illegible] questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding survivability, you may include them in the Remarks section. Survivability as used here refers to the vessel's ability to survive an attack by an enemy.

1. Compared to a WPB, what is the likelihood that this vessel would be damaged by an underwater explosion?

Not observed	___	About the same	6
Much more likely	2	Less likely	___
More likely	2	Much less likely	2

2. What underwater features of this craft make it more or less susceptible to damage?

Not applicable	___	Hull shape	2
Hull plating thickness	5	Amount of hull in water	1
Size and type of appendages	4		
Other (explain)	3	SEALS	

3. Compared to a WPB, what is the likelihood that this vessel would be damaged by an air blast?

Not observed	___	About the same	4
Much more likely	1	Less likely	1
More likely	4	Much less likely	___

4. What above-water features make it more or less susceptible to damage?

Not applicable	___	Antennas and masts	1
Plating thickness	5	Area of plating	3
Other (explain)	1	ALUM. HULL	

5. What other features of the craft make it more or less susceptible to damage than a WPB?

		More Susceptible	Less Susceptib
Speed		3	8
Maneuverability		1	7
Size		9	
Magnetic signature			4
Other (explain)	HULL MATERIAL	1	

6. Remarks. Comment on any other factors affecting survivability that you choose

QUESTIONNAIRE 33A - INTEROPERABILITY AND LOGISTICS

VESSEL NAME ______________________________

YOUR NAME ______________________ DATE ____________

TIME ON BOARD ______________________

This questionnaire covers some of the aspects of operating this vessel with other Coast Guard units and of resupplying the vessel. Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding operations with other units and logistic support, you may include them in the Remarks section.

1. Is fuel readily available for this vessel?

Not observed			
Yes	14	No	___

2. How would you compare the difficulty of fueling this vessel to a WPB?

Not observed	___	About the same	6
Much easier	___	Somewhat more difficult	5
Somewhat easier	___	Much more difficult	1

3. What is the principal reason for fueling being easier or more difficult?

MANY TANKS NO TRANSFER PUMPS

4. Compared to a WPB, was this vessel restricted in the piers available for mooring by any of the following?

Not observed		Draft	7
Beam	6	Length	1
Special features (hull appendages, etc.)	___		
Other (explain)	___	___	

5. Compared to a WPB, how difficult was it to load and stow supplies (food, spare parts, and consummables) on this vessel?

Not observed	___	About the same	3
Much easier	2	Somewhat more difficult	1
Somewhat easier	5	Much more difficult	___

6. What was the principal reason for it being easier or more difficult?

MORE ROOM, SMALLER HATCHES & DOORS

7. What major items of spare parts, peculiar to this type of vessel, do you think will be required frequently?

ENGINE PARTS, SEALS

8. Have you observed this vessel operating jointly with a helicopter?

Yes 12 No 4

9. Compared to a WPB, how difficult would it be for a helo to lift an injured person from the deck of this vessel?

Not observed		About the same	
Much easier	8	Somewhat more difficult	
Somewhat easier	2	Much more difficult	

10. Compared to a WPB, how difficult would it be to conduct combined searches using this vessel and a helo?

Not observed		About the same	2
Much easier	5	Somewhat more difficult	
Somewhat easier	2	Much more difficult	

11. What principal factor makes it easier or more difficult?

SPEED, BETTER MANEUVERABILITY, SIZE, STABILITY

12. What other aspects of ship-helo operations are noteworthy with regard to this vessel?

MORE ROOM

13. Have you observed combined operations between this vessel and another CG cutter?

Yes 12 No 6

14. Compared to a WPB, how difficult is it to conduct combined operations with another CG cutter?

Not observed		About the same	2
Much easier	2	Somewhat more difficult	1
Somewhat easier	4	Much more difficult	

15. What is the principal factor that makes it easier or more difficult to conduct combined operations?

____

16. How would you compare refueling this vessel alongside a larger CG cutter to the same operation on a WPB?

Not observed	___	About the same	1
Much easier	1	Somewhat more difficult	___
Somewhat easier	4	Much more difficult	___

17. How would you compare other replenishment operations alongside to a WPB?

Not observed	___	About the same	1
Much easier	2	Somewhat more difficult	1
Somewhat easier	4	Much more difficult	___

18. Has your vessel relieved a tow or passed a tow to another CG vessel while you were aboard?

Yes	10	No	7

19. Compare the difficulty of relieving or passing a tow to doing the same operation on a WPB?

Not observed	___	About the same	___
Much easier	4	Somewhat more difficult	___
Somewhat easier	4	Much more difficult	___

20. What principal factor made passing a tow easier or more difficult?

MORE ROOM, STABLE WORK PLATFORM, MANEUVERABILITY

21. Are there hull appendages or other structures likely to be damaged while towing or while picking up or passing a tow?

Not observed			
Yes	1	No	9

22. If yes, what appendages or structures?

SCREWS EXPOSED

23. Is more or less training required to operate and maintain this vessel than is required for a WPB?

Not observed	___	About the same	7
Much more	1	Somewhat less	___
Somewhat more	1	Much less	___

24. What types of training need to be given which are peculiar to this type of vessel?

SPECIAL ENGINEERING, DESIGN OF SES — CONSCIENCIOUSNESS OF LIQUID L

TRIM, CG — LIFT FAN OPERATIONS

ALUMINUM MAINTENANCE

25. What types of training are required on a WPB that are not required on this vessel?

26. Overall, how would you rate the problems of keeping this vessel supplied with fuel, consummables, and spare parts compared to a WPB?

Not observed	___	About the same	5
Much easier	___	Somewhat more difficult	___
Somewhat easier	2	Much more difficult	___

27. Overall, how would you rate the problems of operating this vessel with other CG units compared to operating a WPB with other CG units?

Not observed	___	About the same	1
Much easier	2	Somewhat more difficult	___
Somewhat easier	3	Much more difficult	___

28. Remarks. Comment on any aspects of operating with other CG units, resupplying the vessel, and training that you desire. Offer any suggestions you have for making combined operations more efficient. Any craft characteristics which permit new tactics should be noted.

CAN OPERATE EASILY WITH OTHER CUTTERS

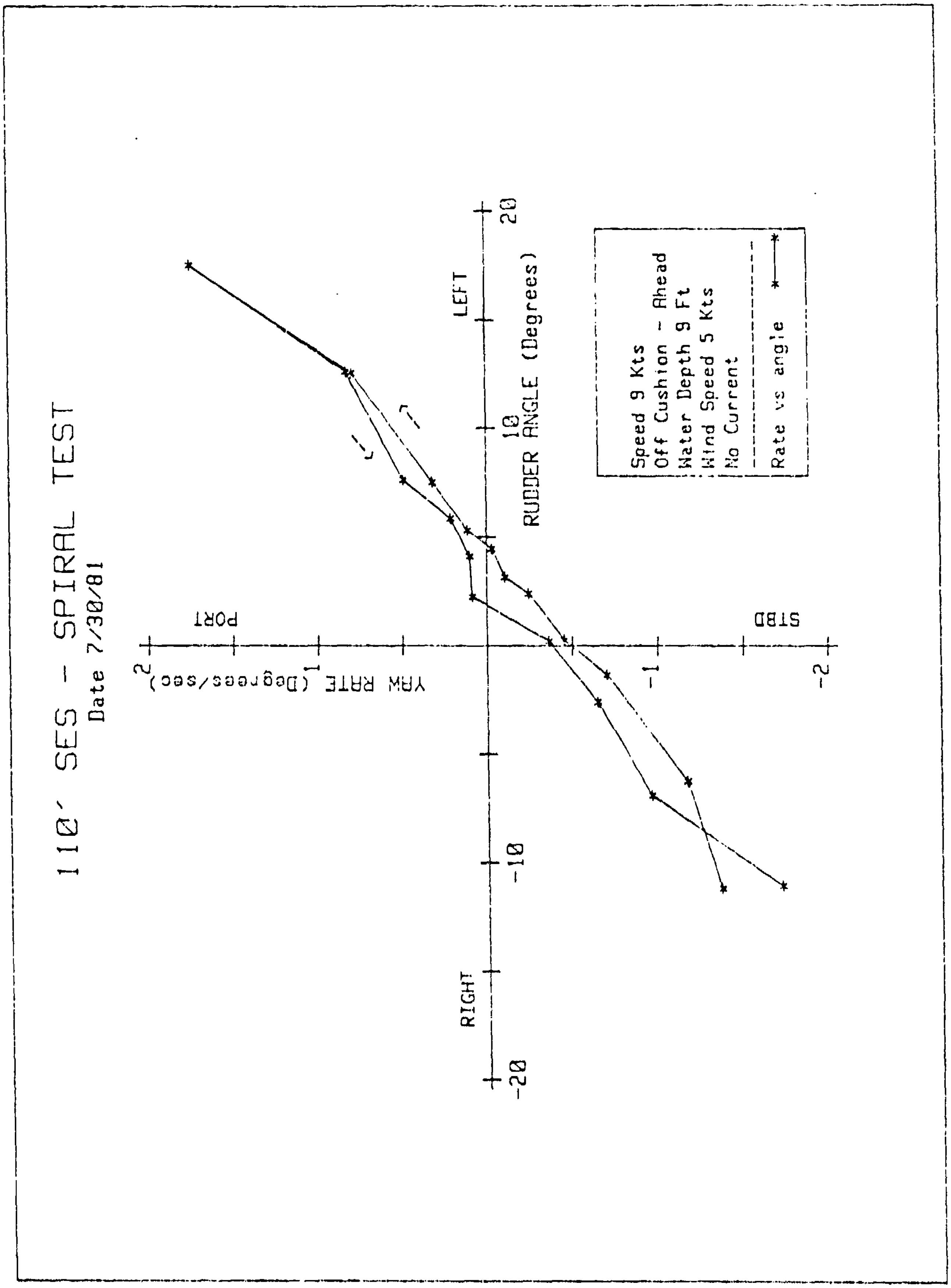


FIGURE A-1
SPIRAL TEST, 9 KTS - OFF CUSHION

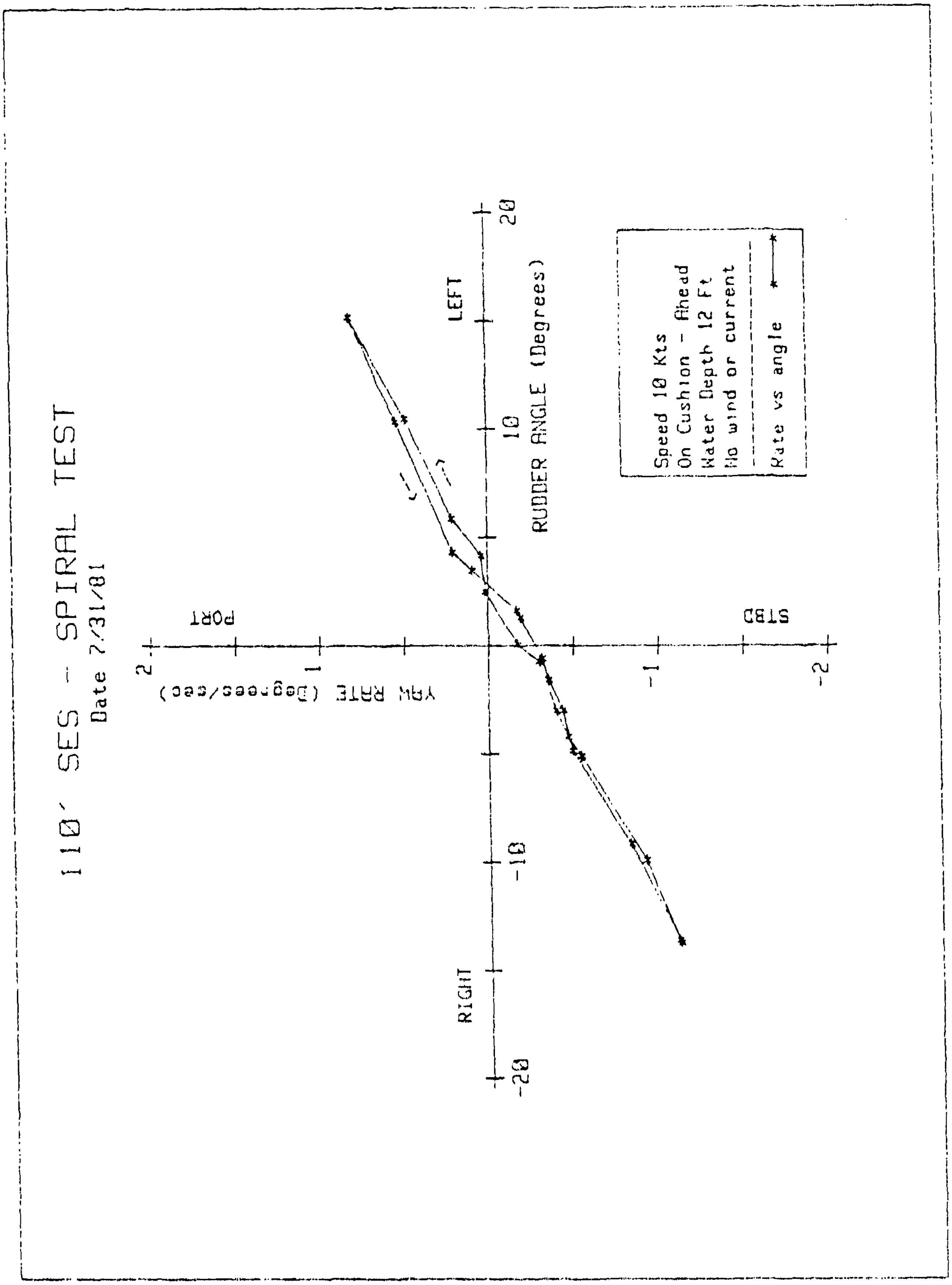


FIGURE A-2
SPIRAL TEST, 10 KTS - ON CUSHION

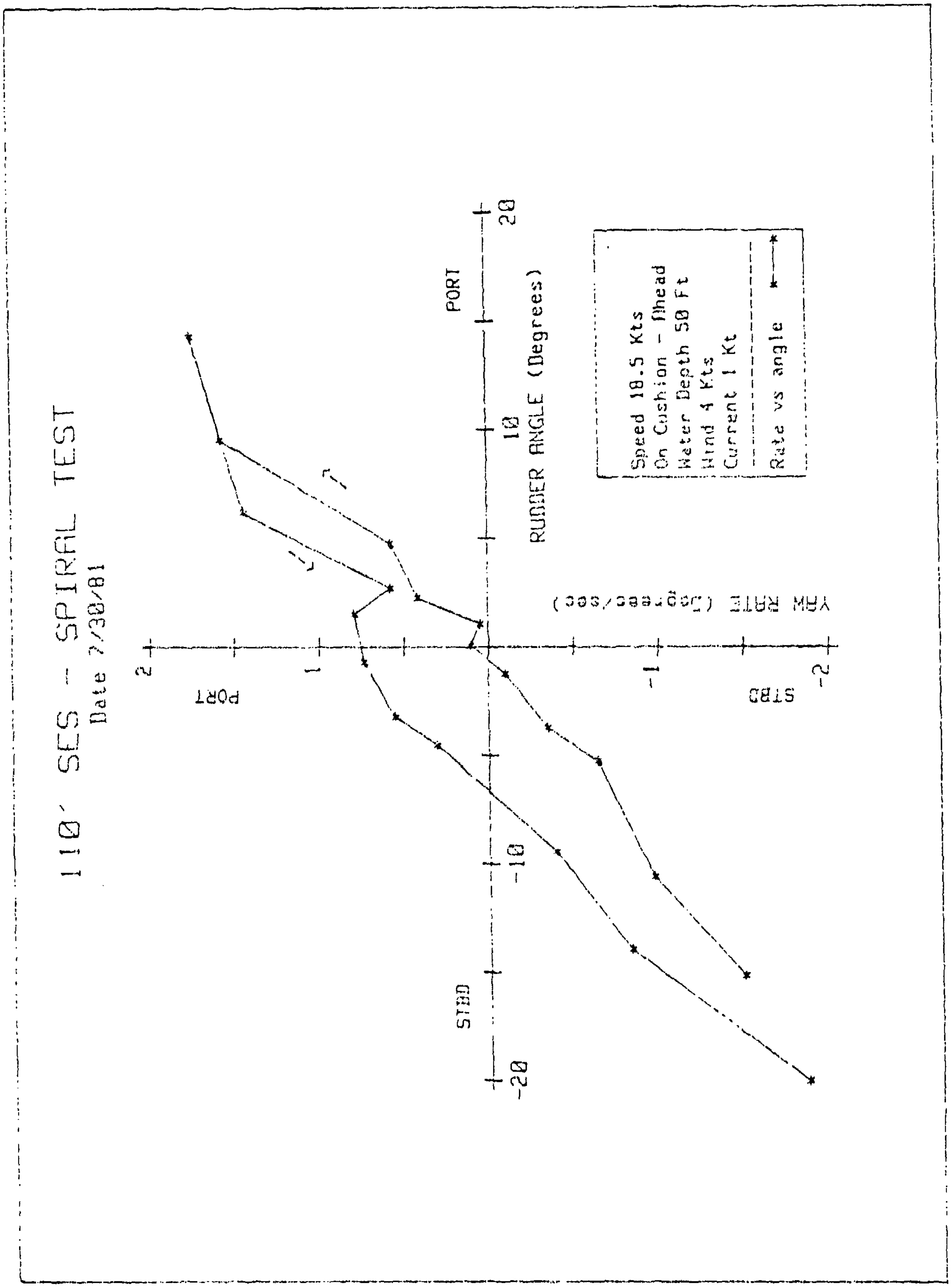


FIGURE A-3
SPIRAL TEST, 18.5 KTS - ON CUSHION

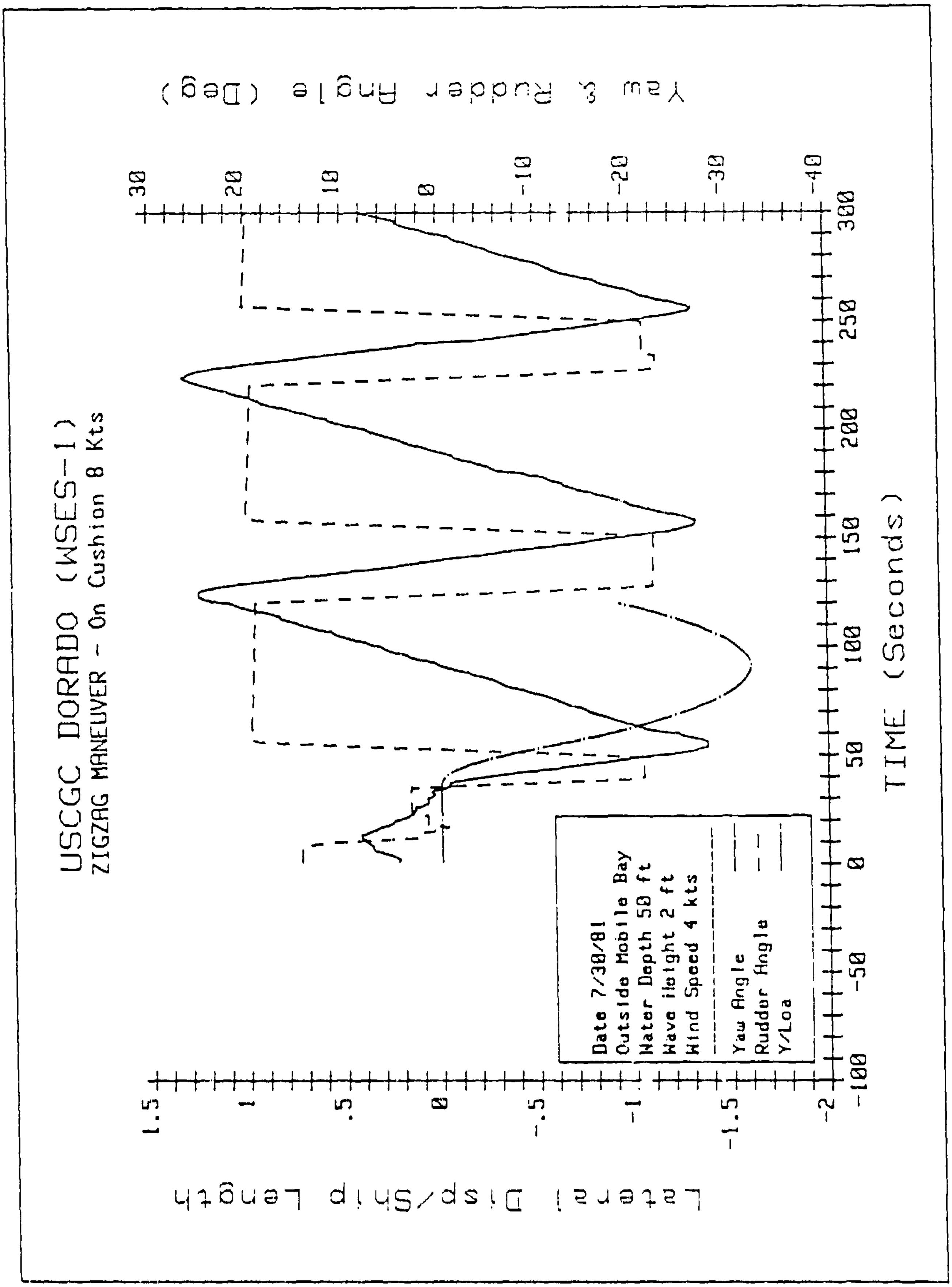


FIGURE A-4
ZIGZAG MANEUVER, 8 KTS - ON CUSHION

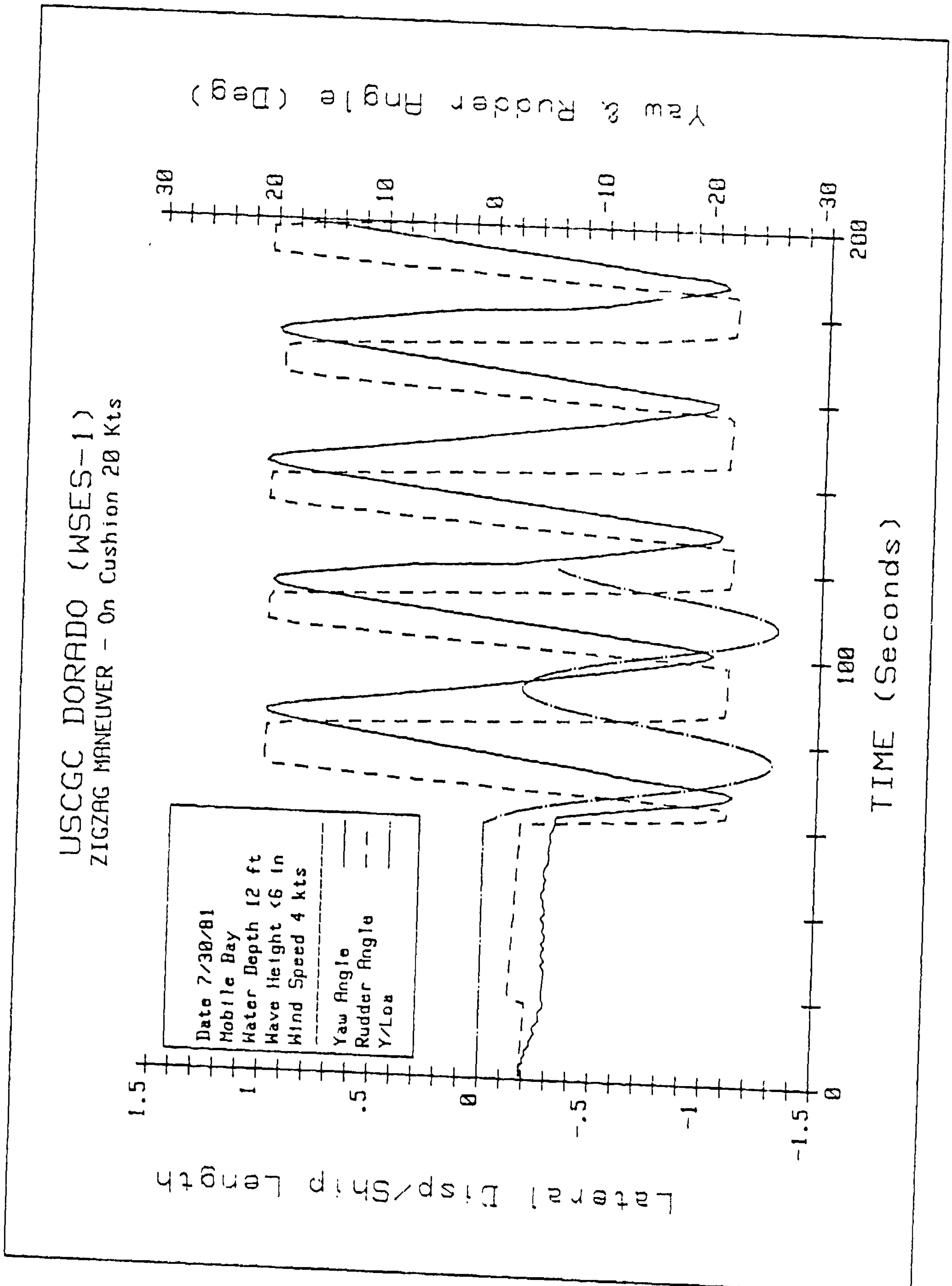


FIGURE A-5
ZIGZAG MANEUVER, 20 KTS - ON CUSHION

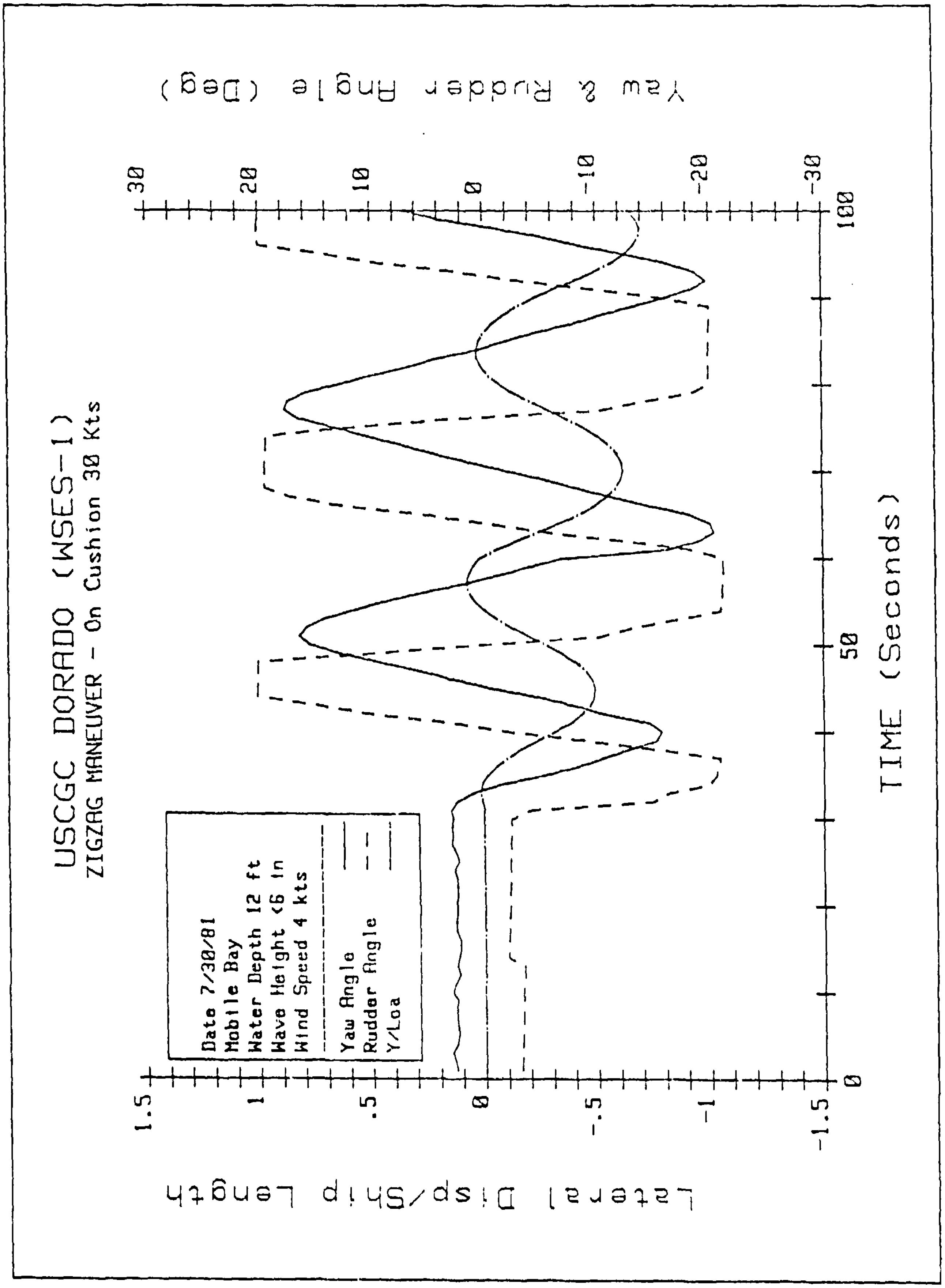


FIGURE A-6
ZIGZAG MANEUVER, 30 KTS - ON CUSHION

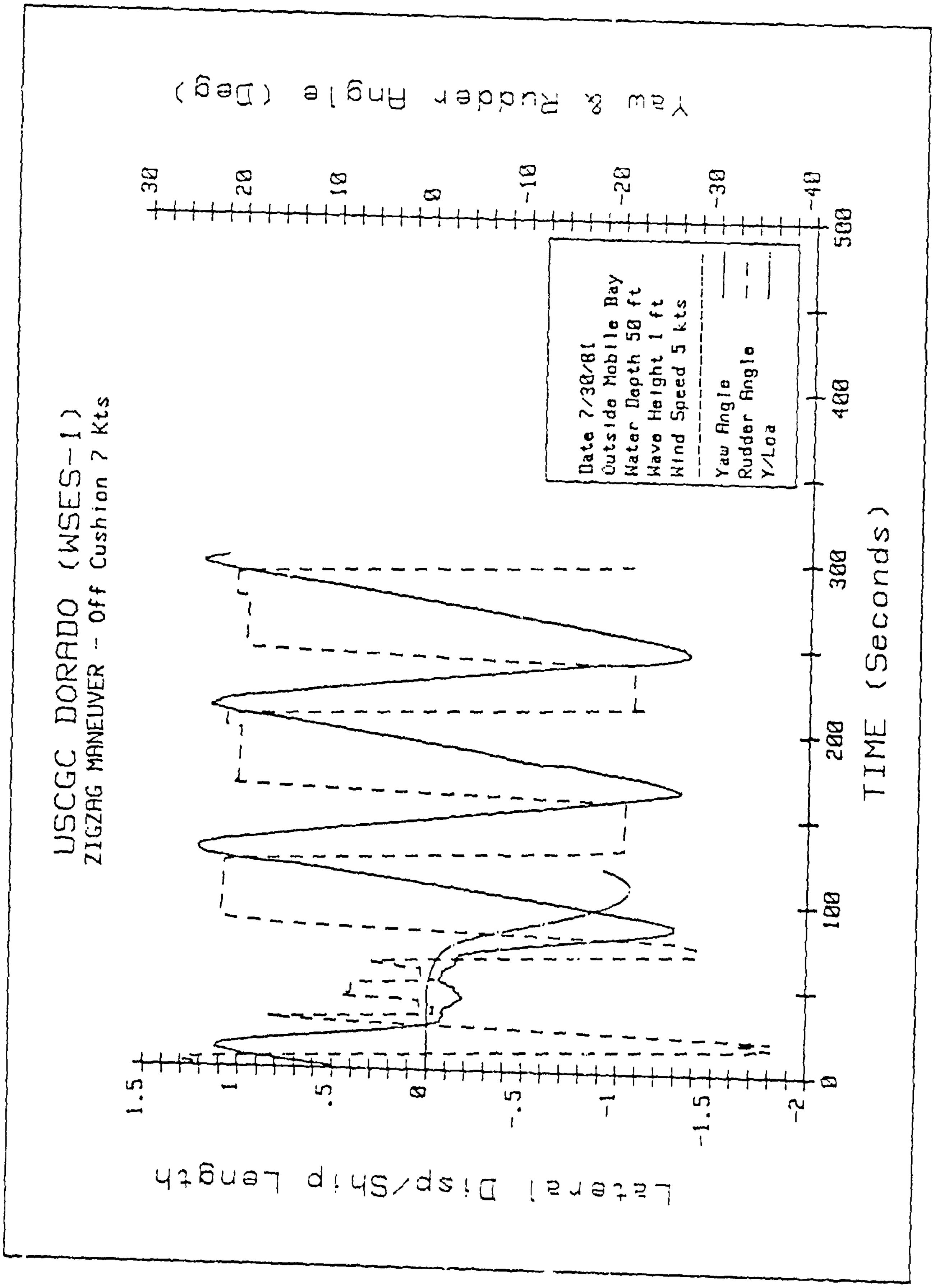
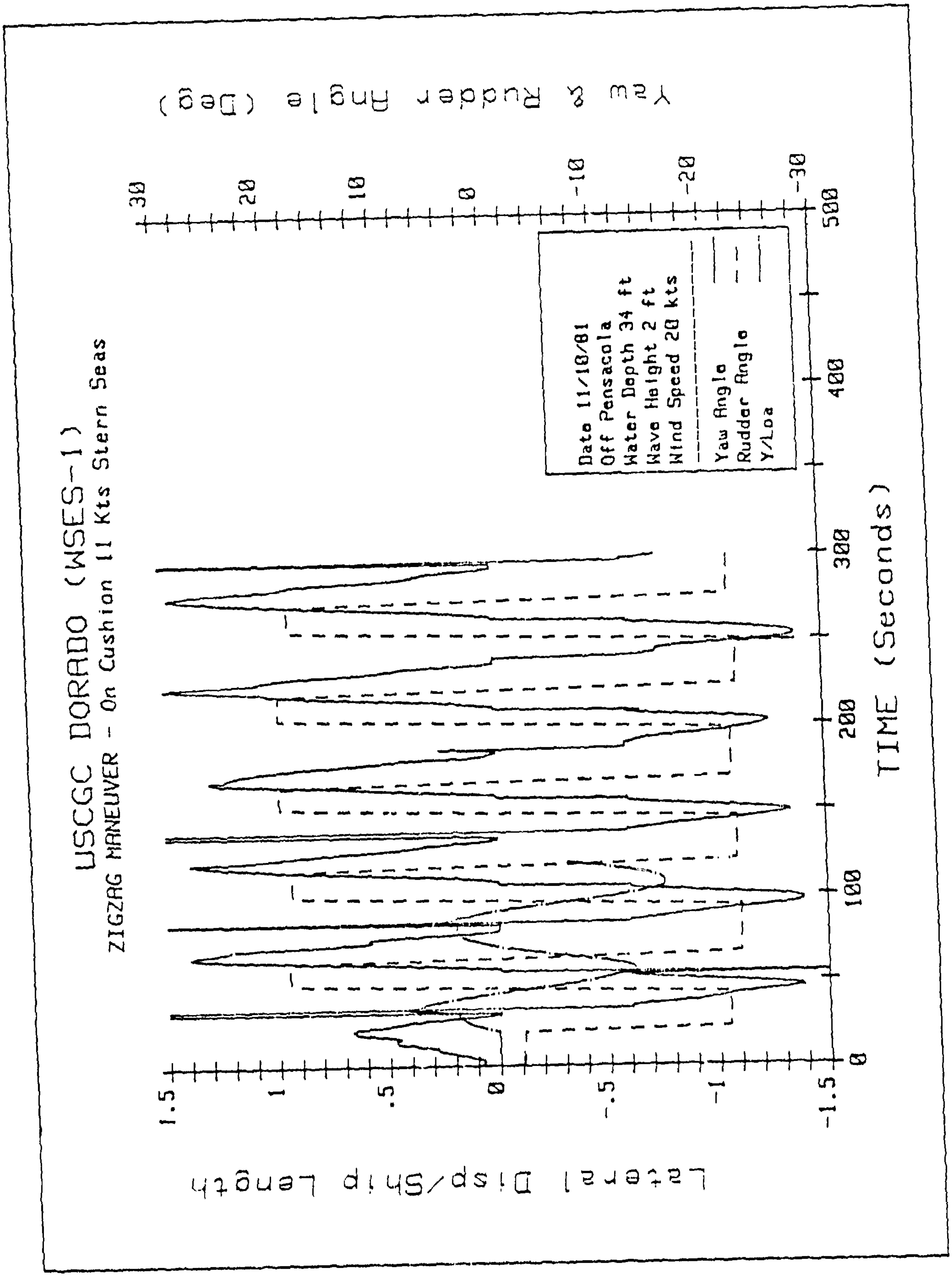


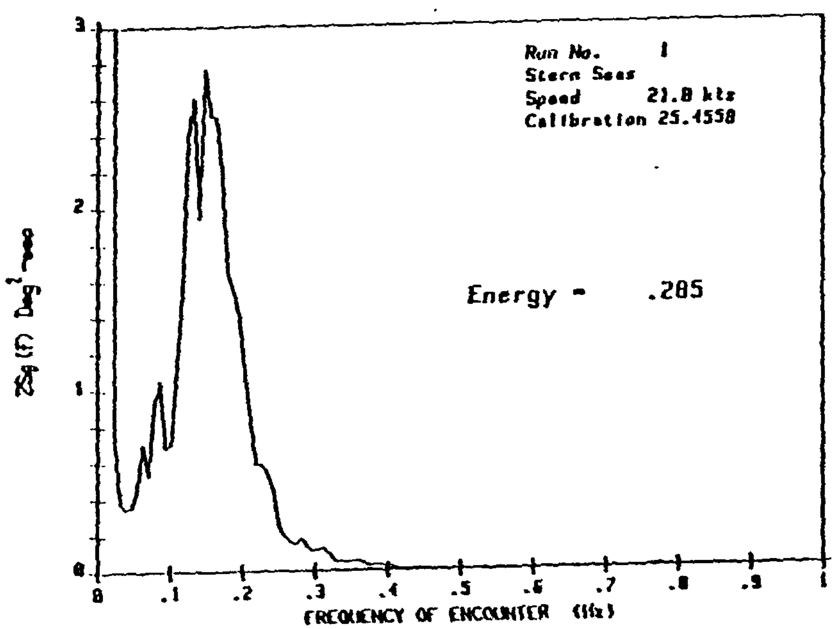
FIGURE A-7
ZIGZAG MANEUVER, 7 KTS - OFF CUSHION



ZIGZAG MANEUVER, 11 KTS - ON CUSHION - STERN SEAS

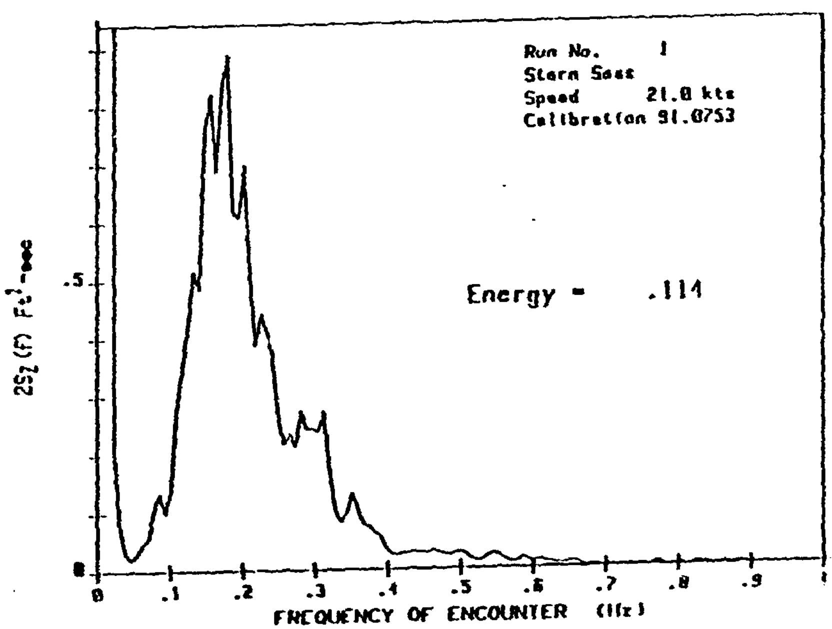
FIGURES A-9 THROUGH A-49
MOTION SPECTRA

USCGC DORADO (WSES-1)
Tested 11/9/81

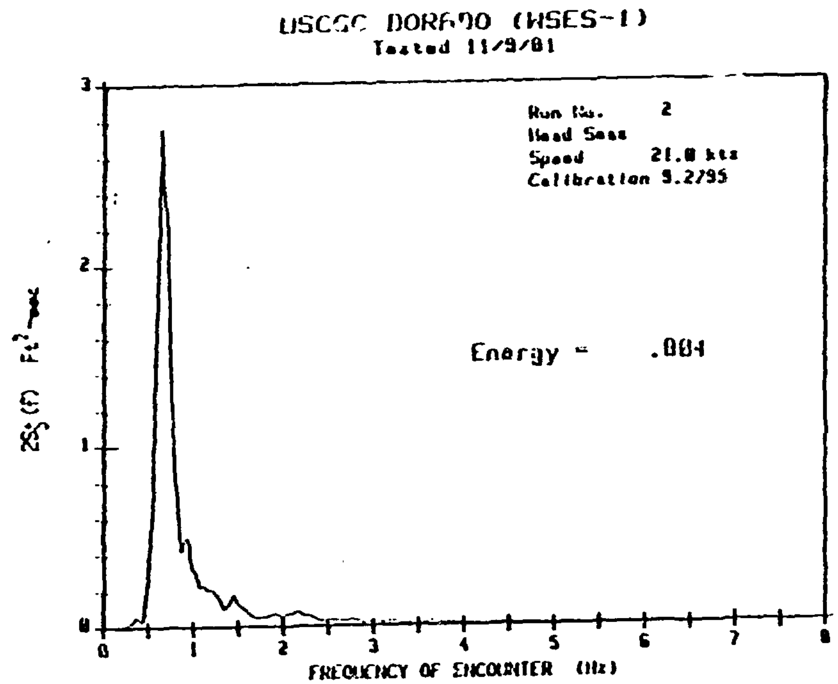


PITCH ENERGY SPECTRUM

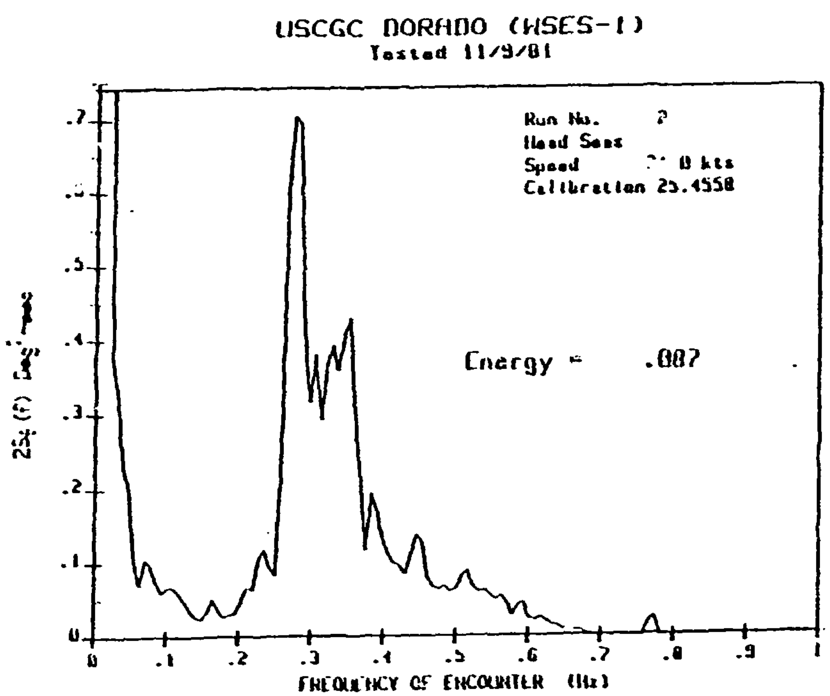
USCGC DORADO (WSES-1)
Tested 11/9/81



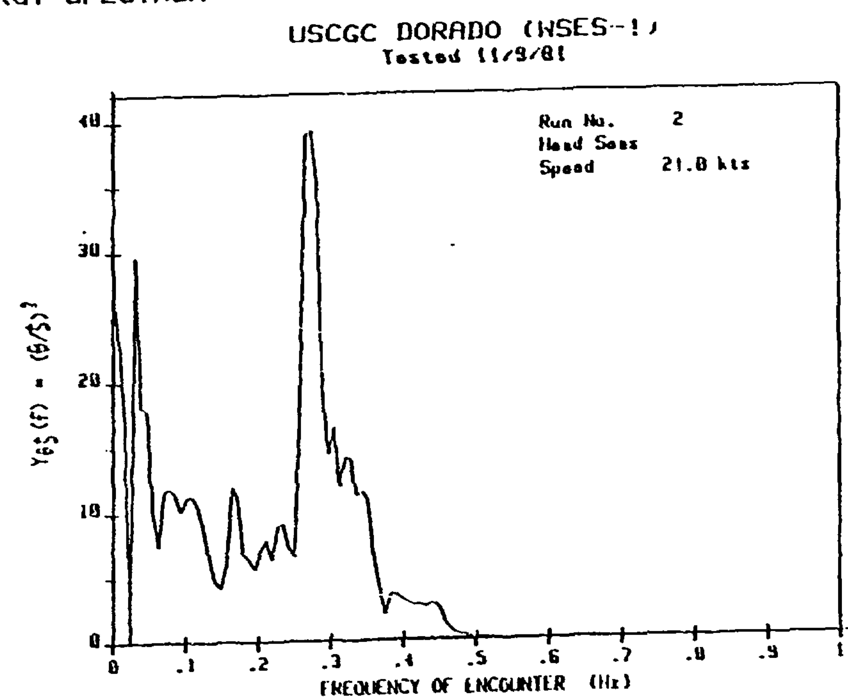
HEAVE ENERGY SPECTRUM



WAVE ENERGY SPECTRUM

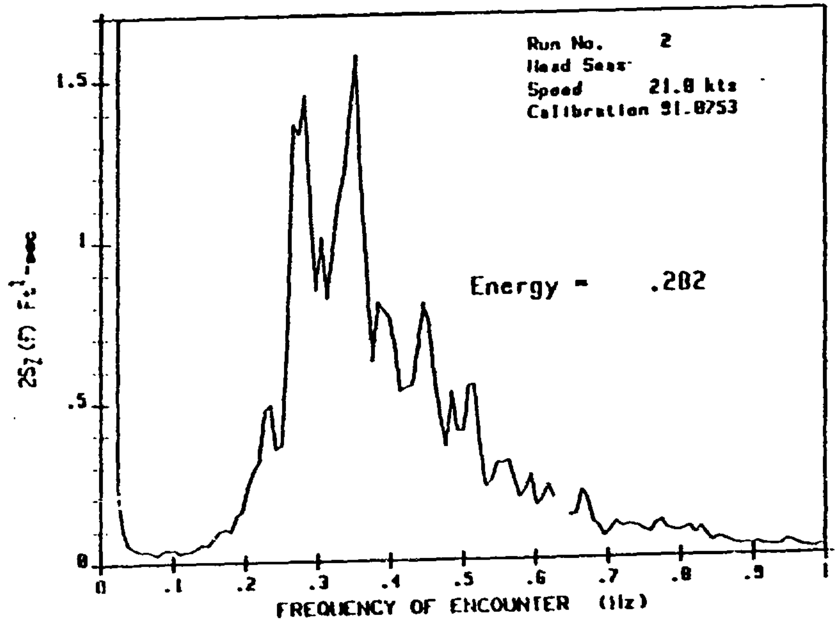


PITCH ENERGY SPECTRUM



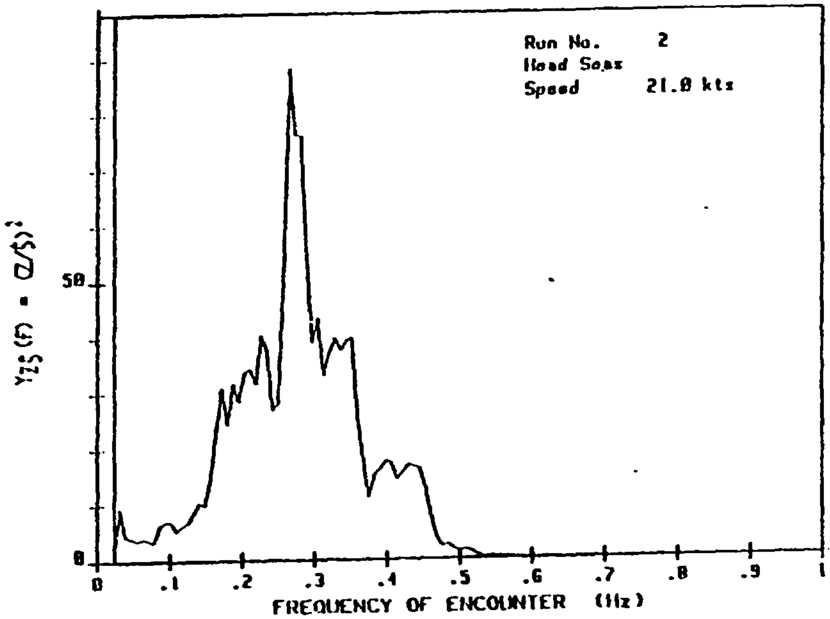
PITCH RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



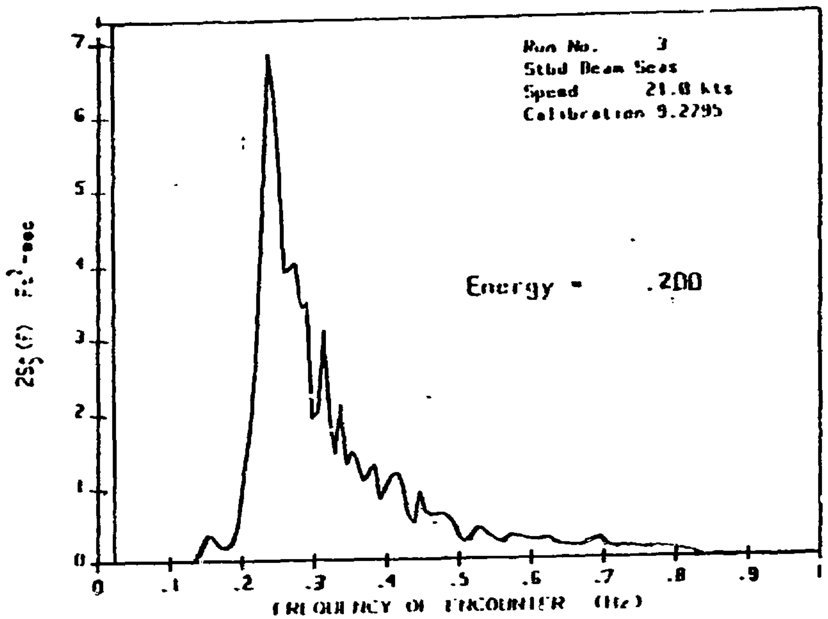
HEAVE ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



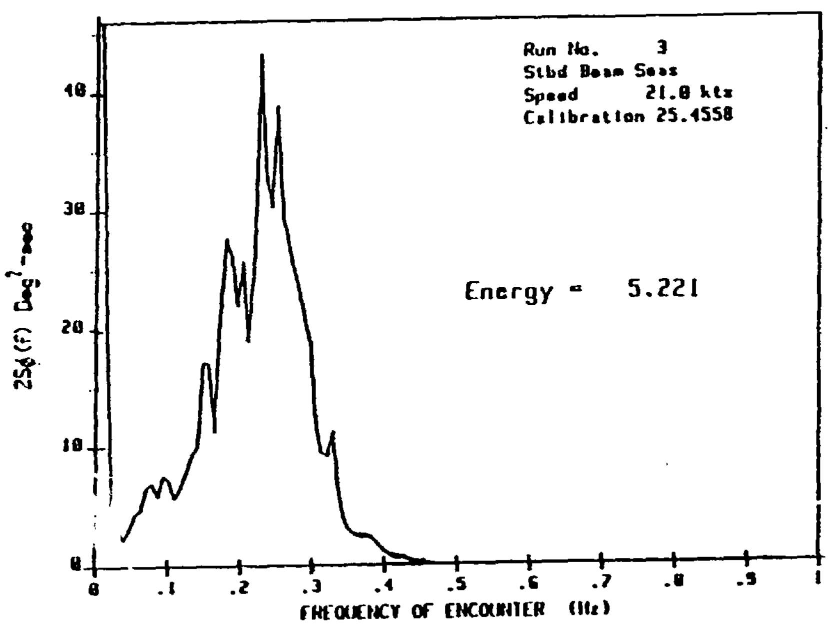
HEAVE RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



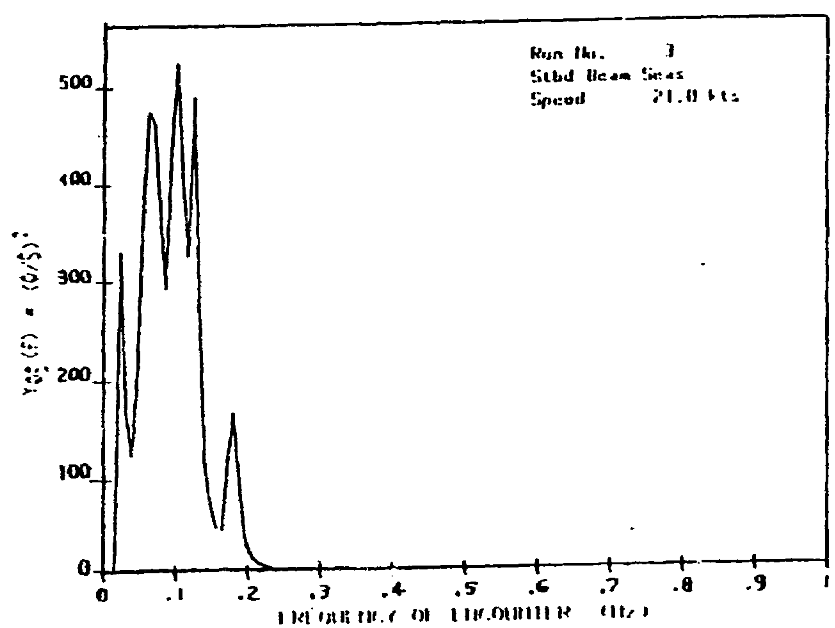
HEAVE ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



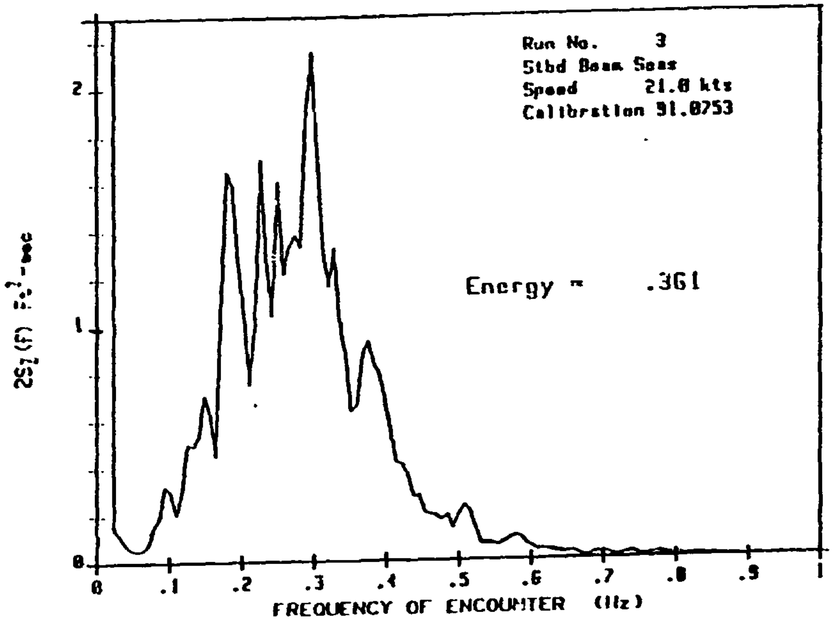
ROLL ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



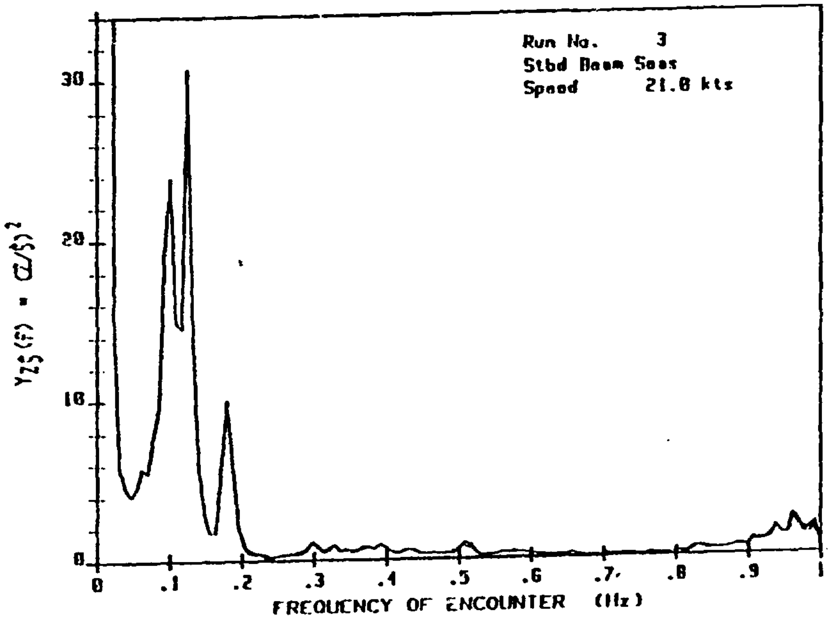
ROLL RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



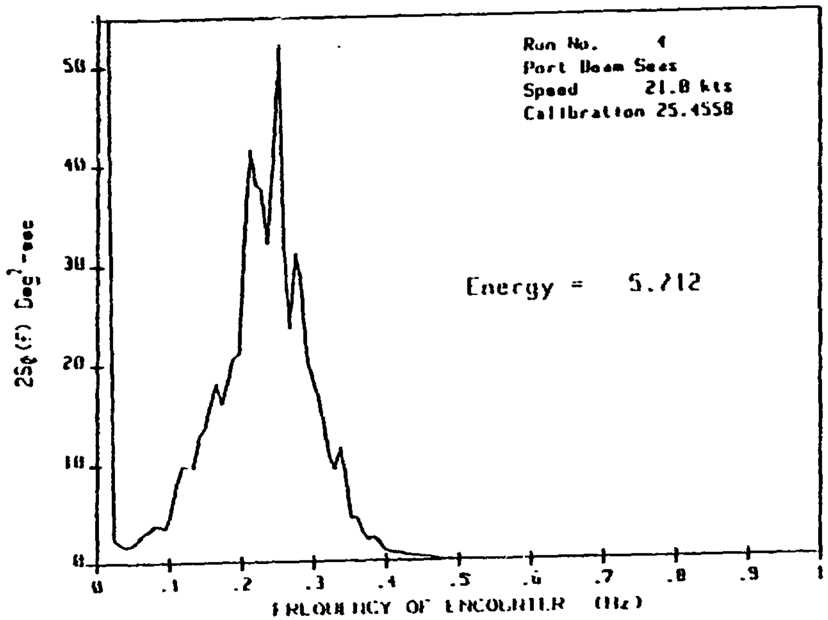
HEAVE ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



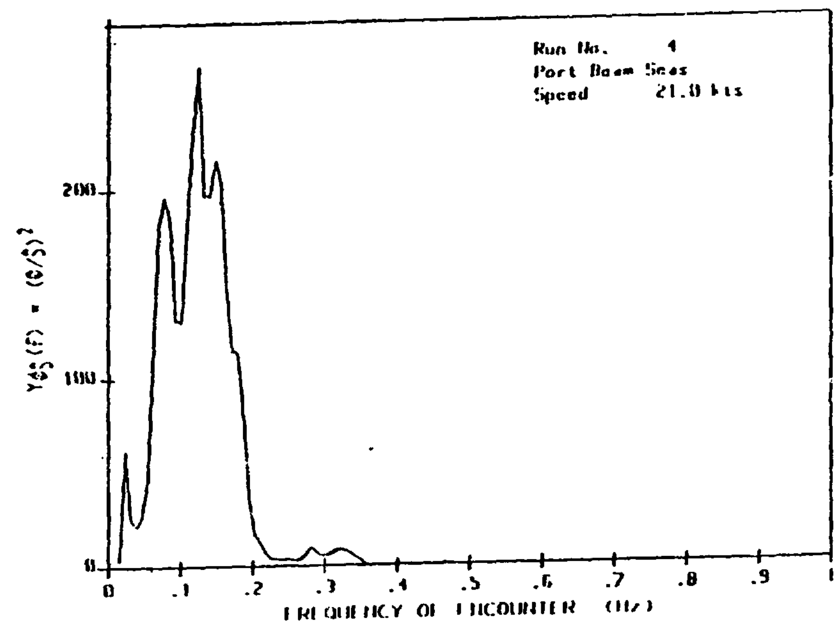
HEAVE RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



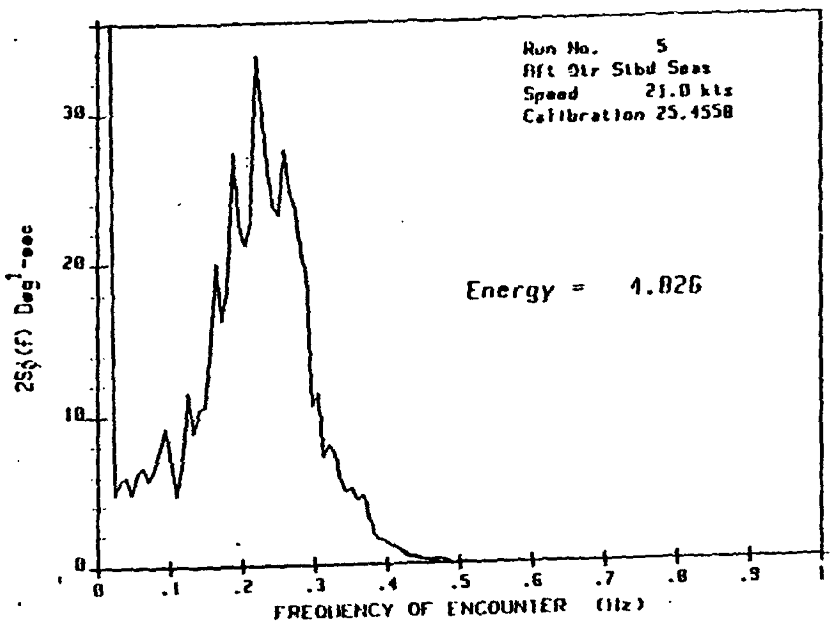
ROLL ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



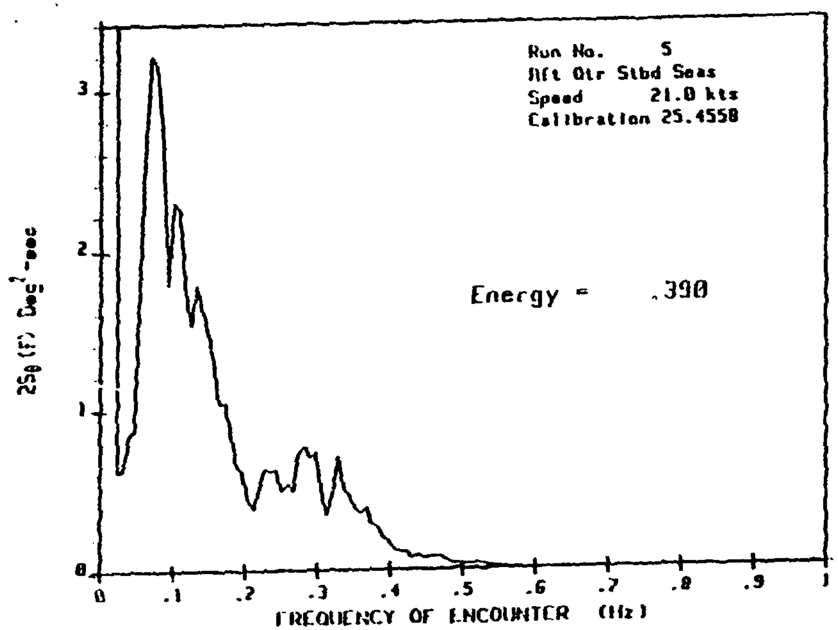
ROLL RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



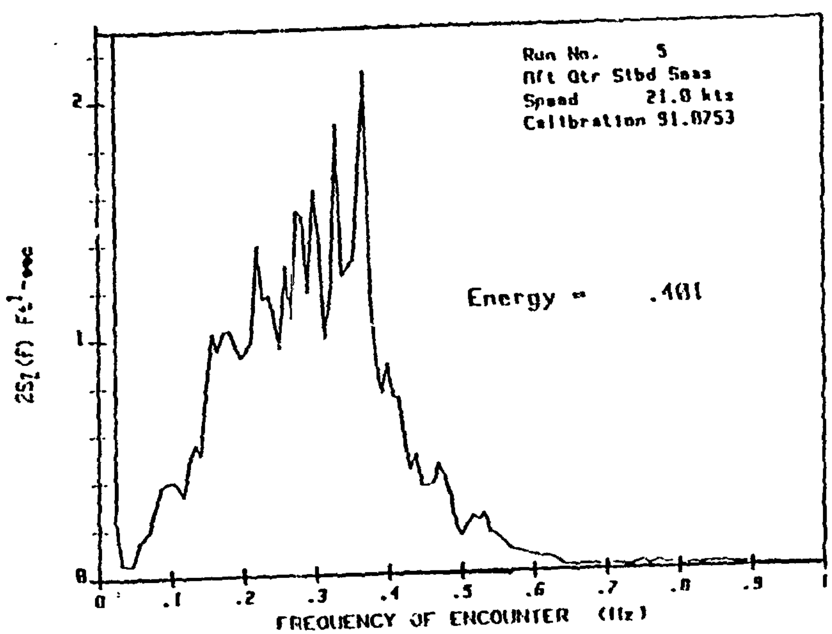
ROLL ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81

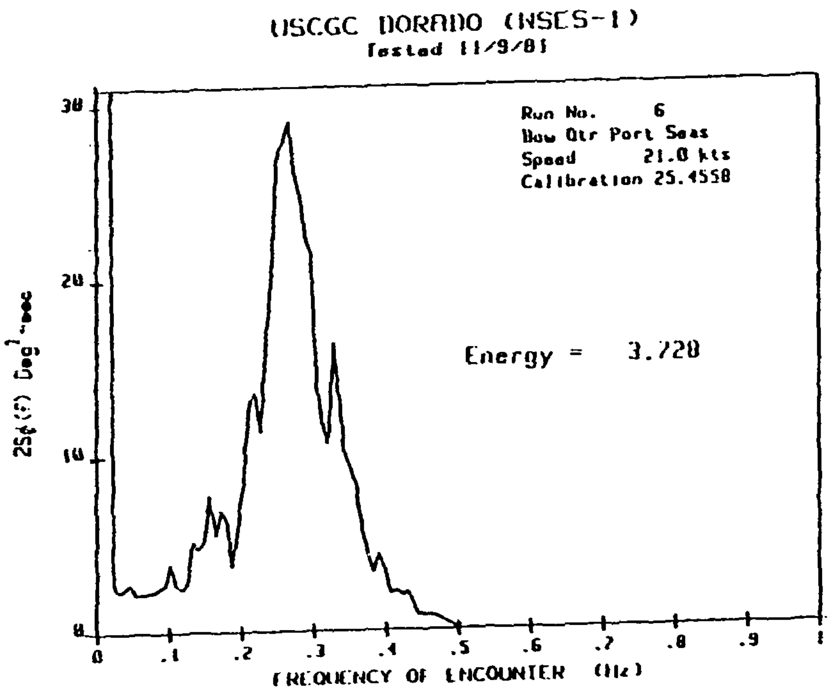


PITCH ENERGY SPECTRUM

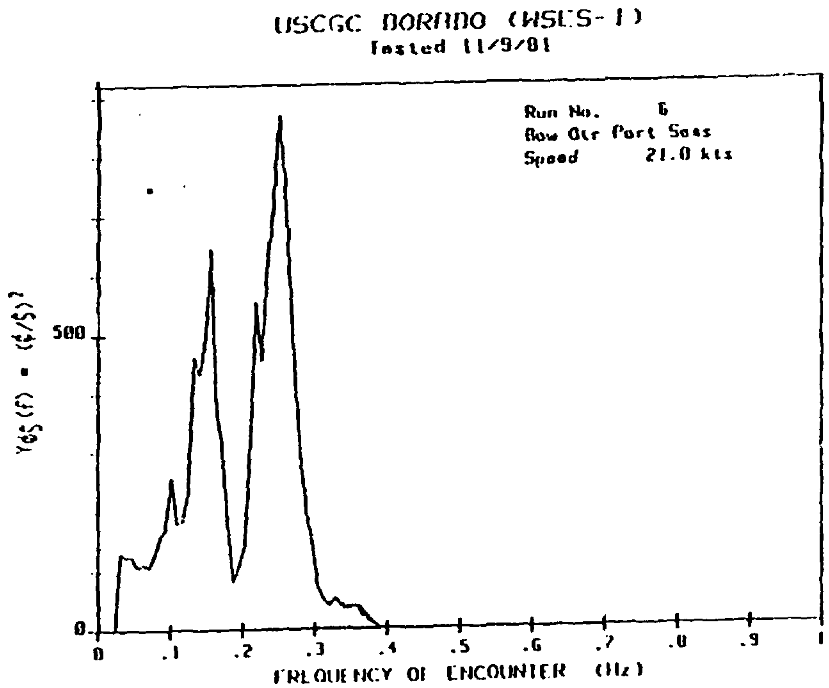
USCGC DORADO (WSES-1)
Tested 11/9/81



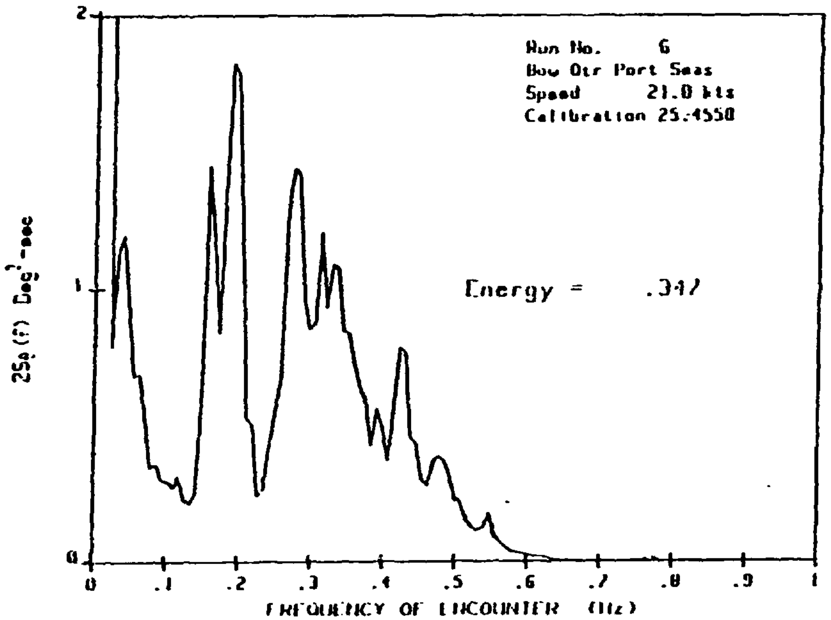
HEAVE ENERGY SPECTRUM



ROLL ENERGY SPECTRUM



ROLL RESPONSE AMPLITUDE OPERATOR



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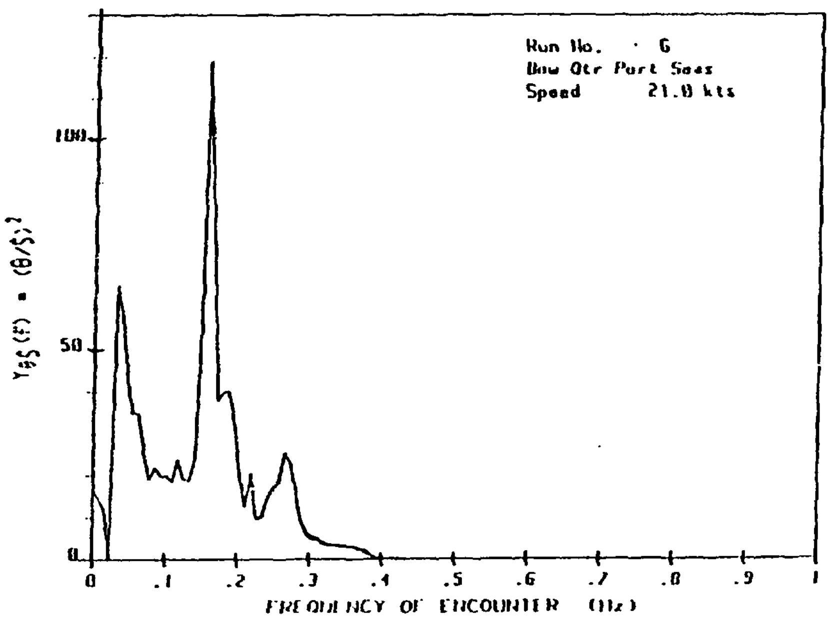
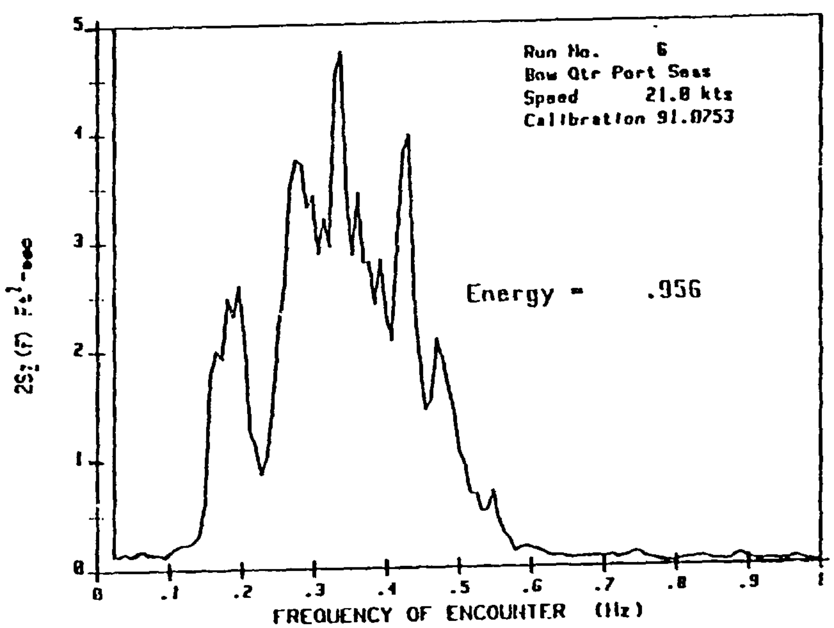


PITCH RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



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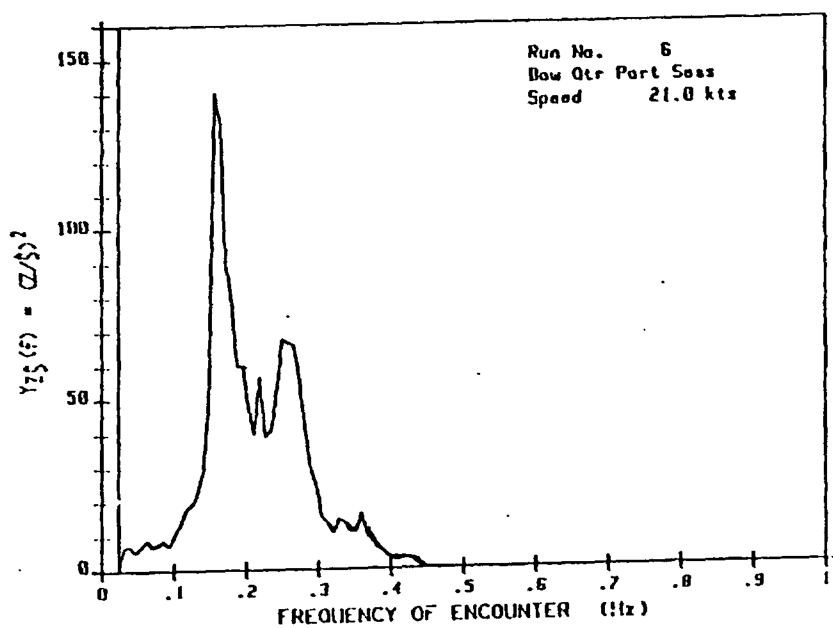
USCGC DORADO (WSES-1)
Tested 11/9/81



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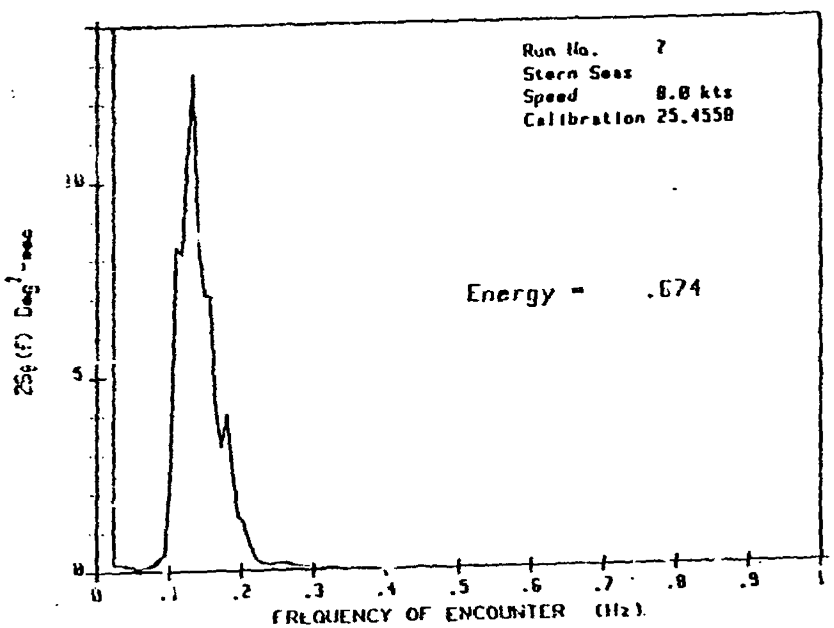
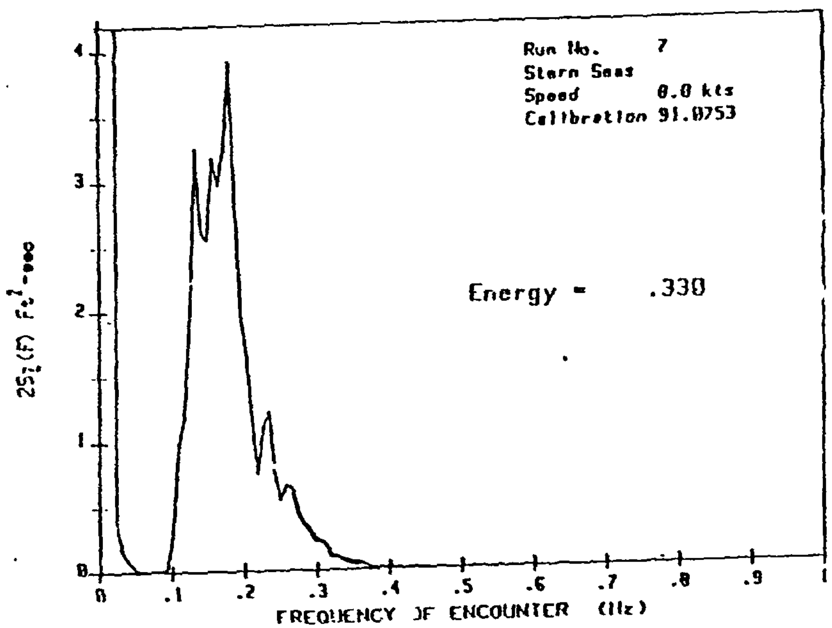
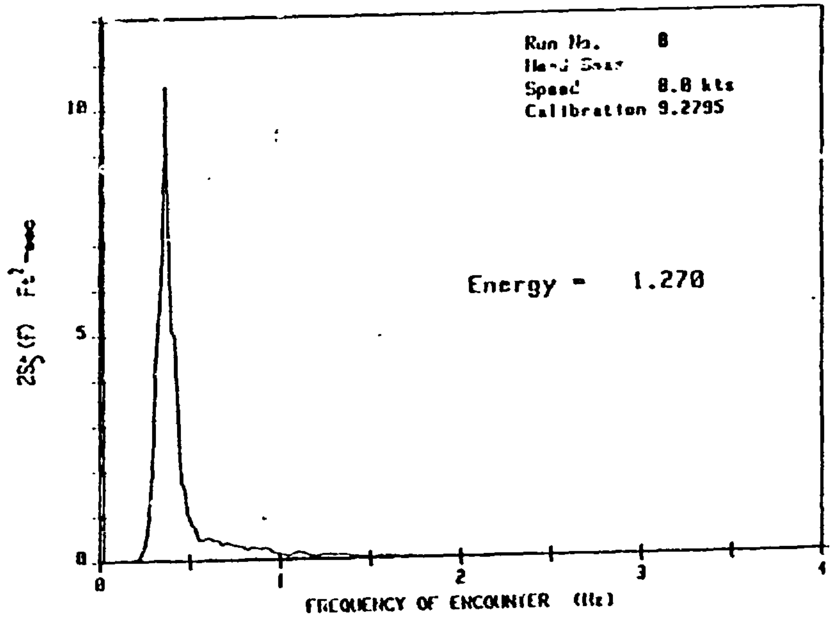


PITCH ENERGY SPECTRUM



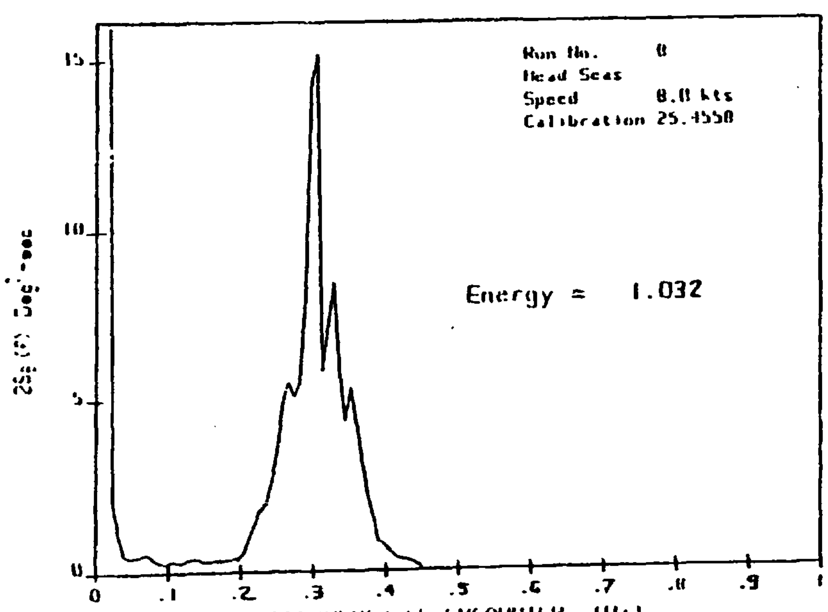
HEAVE ENERGY SPECTRUM

USCGC DORADO (HSES-I)
Tested 11/9/81



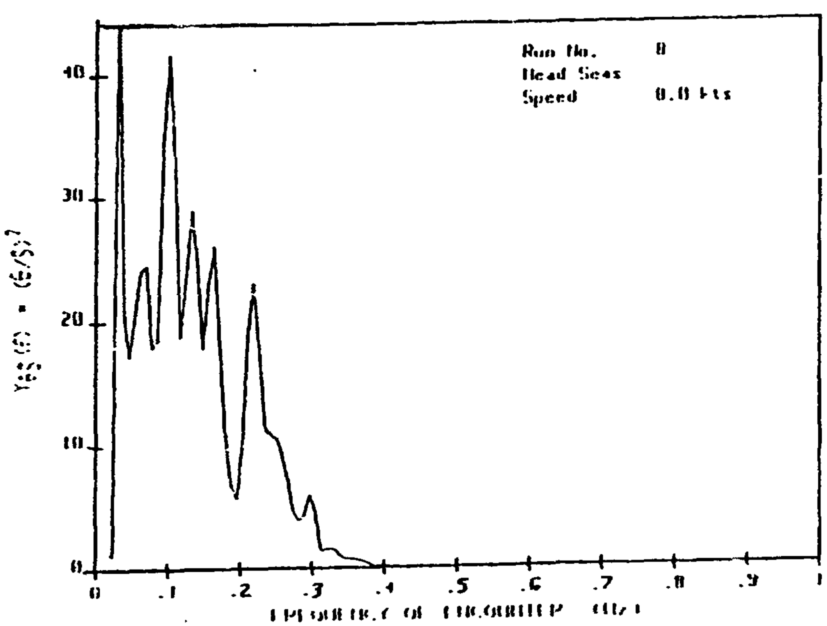
WAVE ENERGY SPECTRUM

USCGC DORADO (HSES I)
Tested 11/9/81



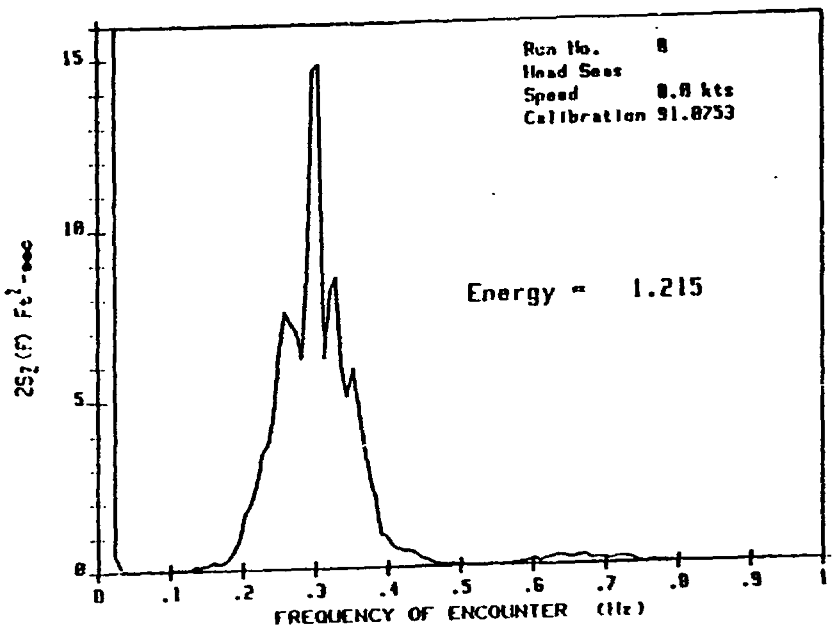
PITCH ENERGY SPECTRUM

USCGC DORADO (HSES I)
Tested 11/9/81



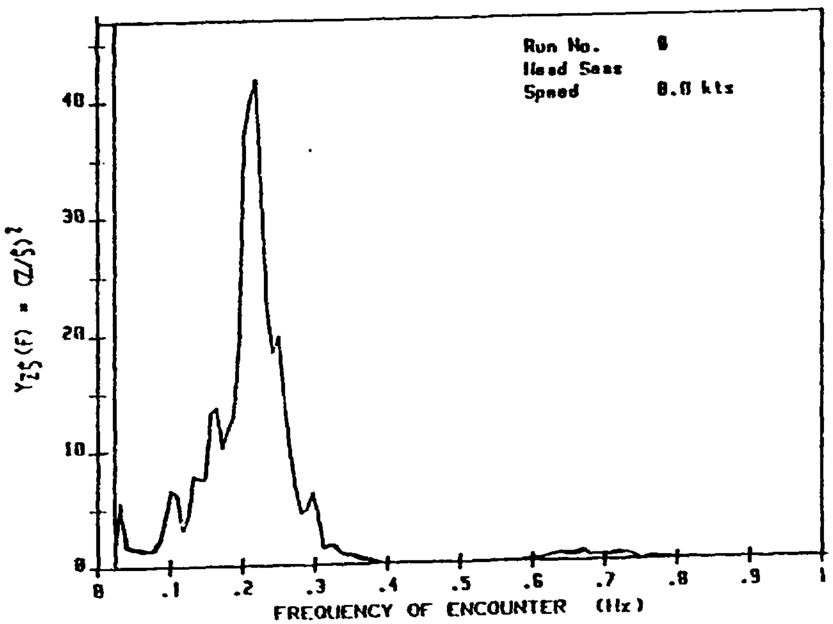
PITCH RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



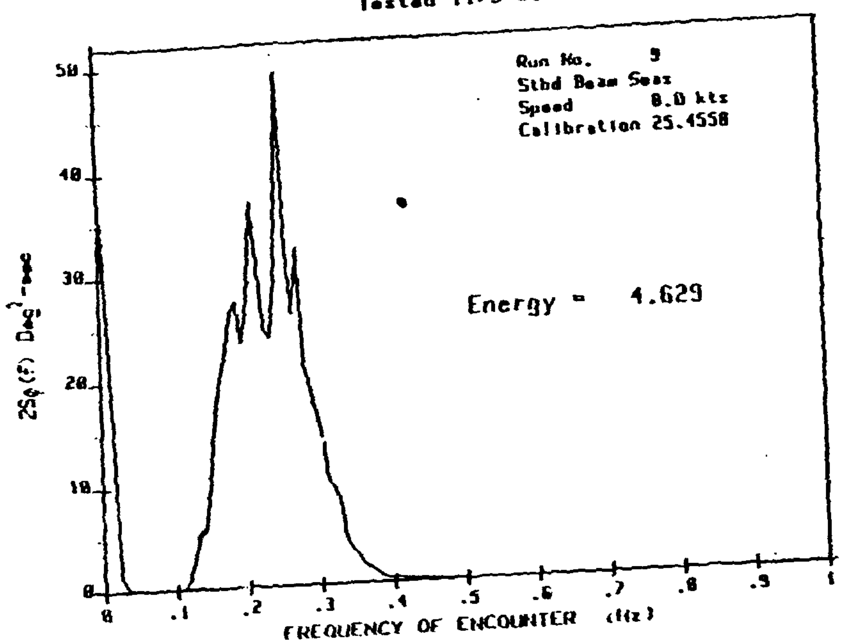
HEAVE ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



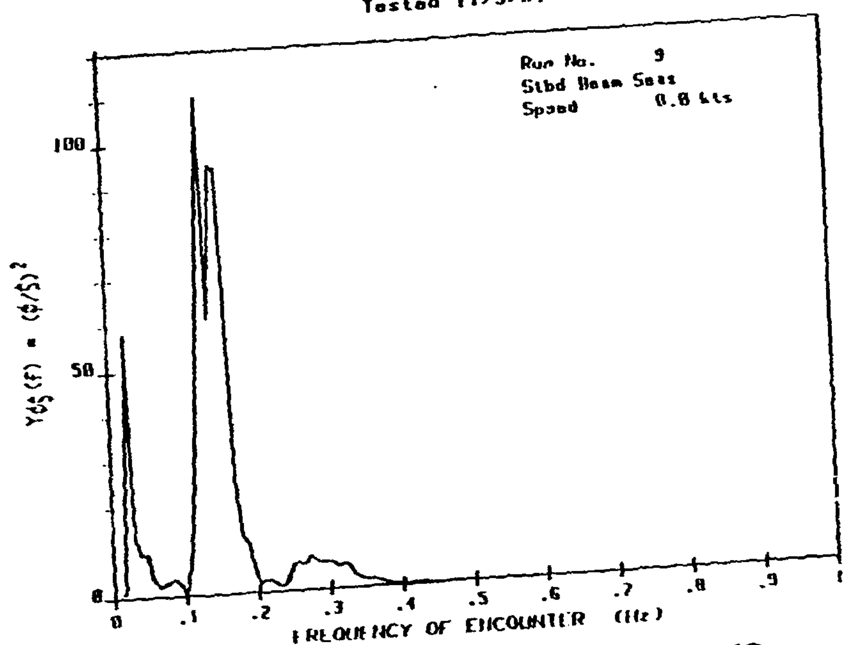
HEAVE RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



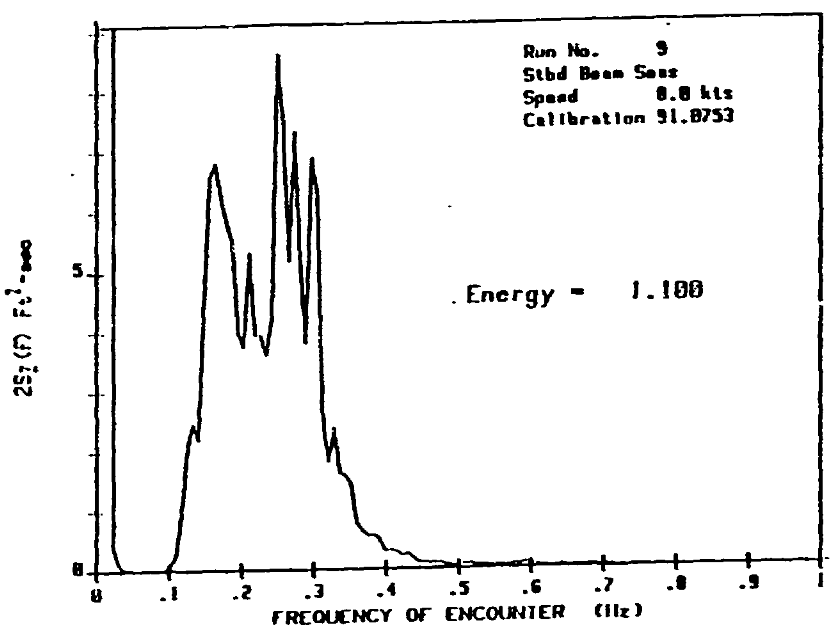
ROLL ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



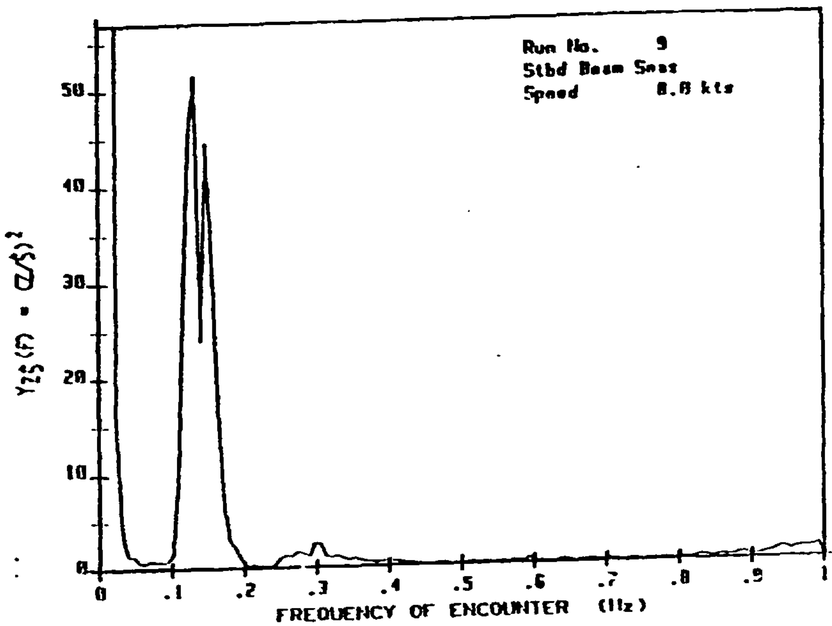
ROLL RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81

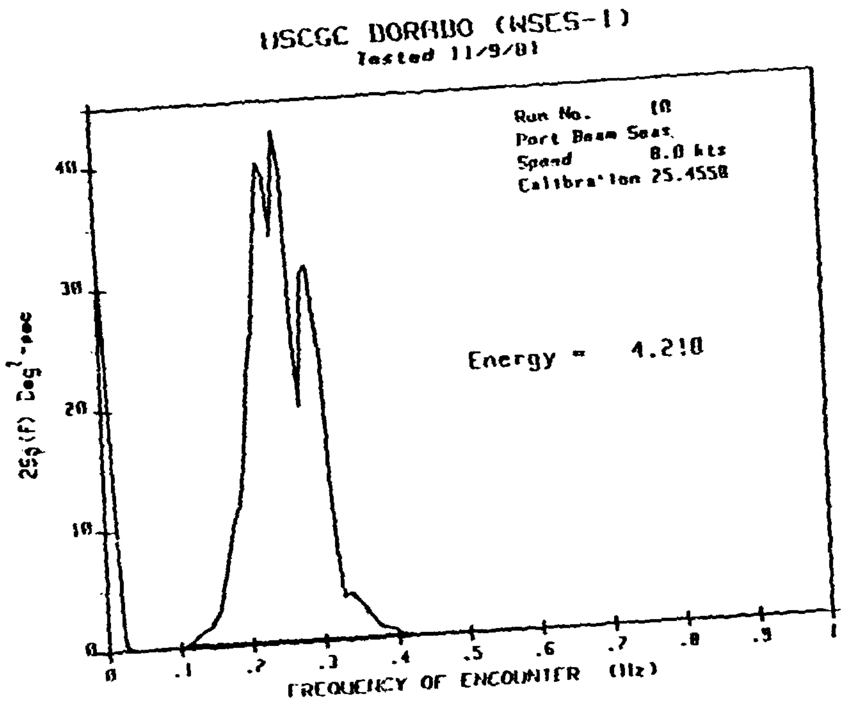


HEAVE ENERGY SPECTRUM

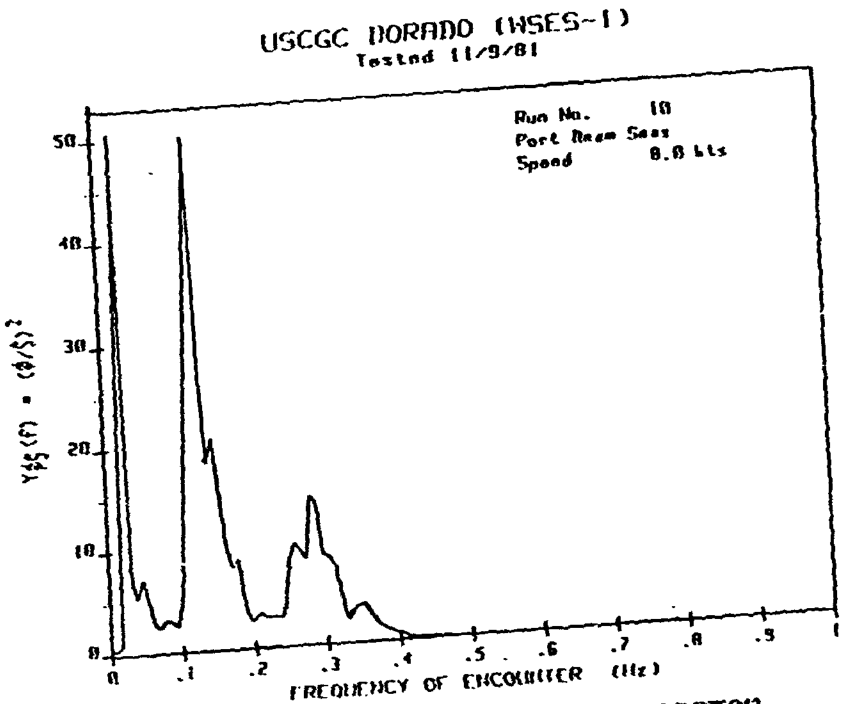
USCGC DORADO (WSES-1)
Tested 11/9/81



HEAVE RESPONSE AMPLITUDE OPERATOR

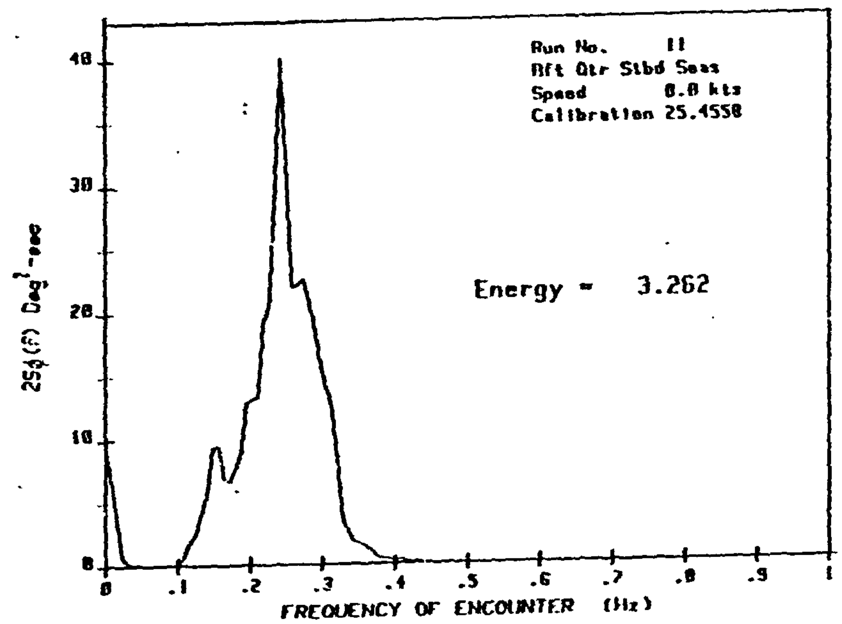


ROLL ENERGY SPECTRUM



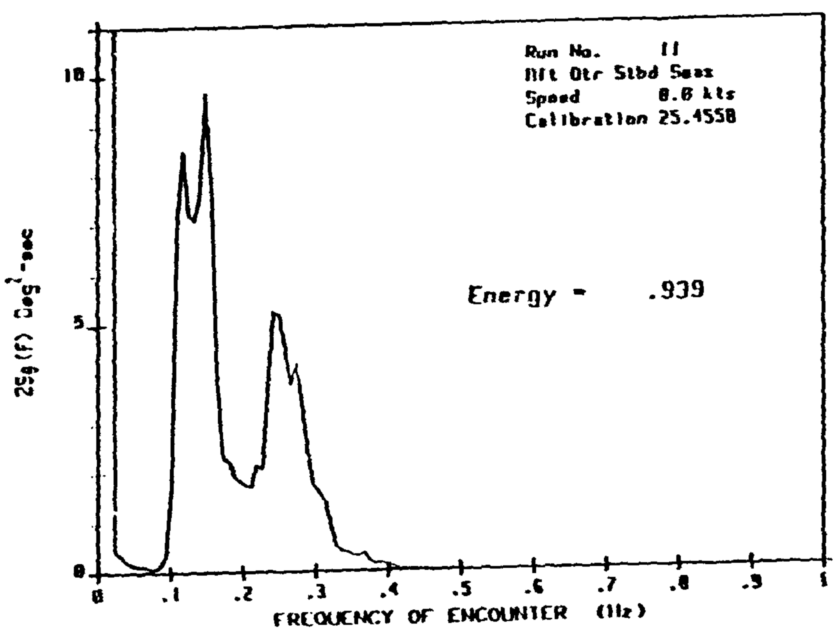
ROLL RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81



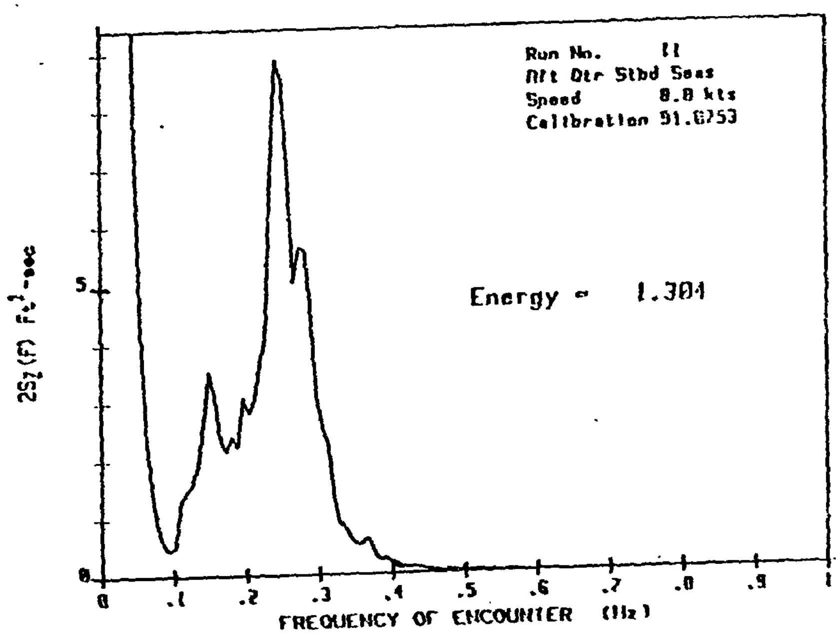
ROLL ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



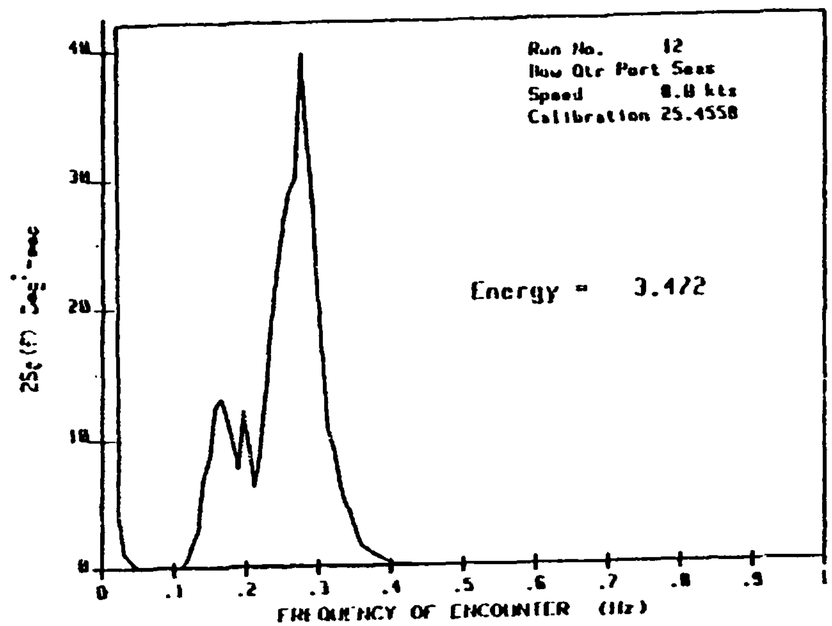
PITCH ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



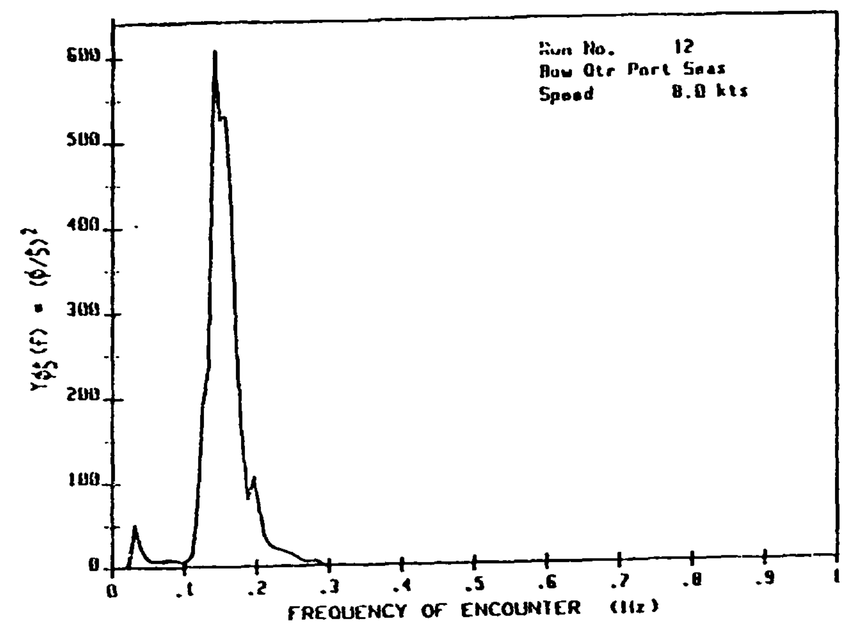
HEAVE ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



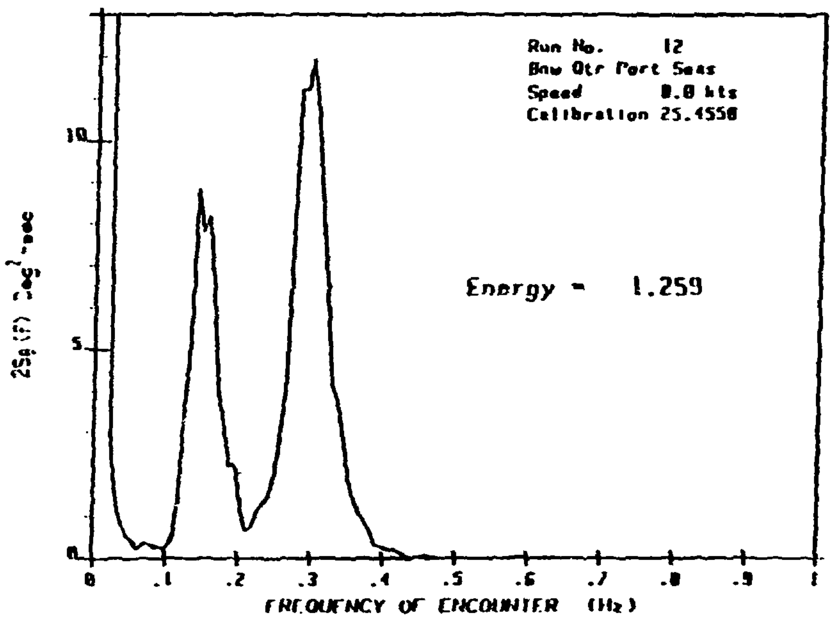
ROLL ENERGY SPECTRUM

USCGC DORADO (WSES-1)
Tested 11/9/81



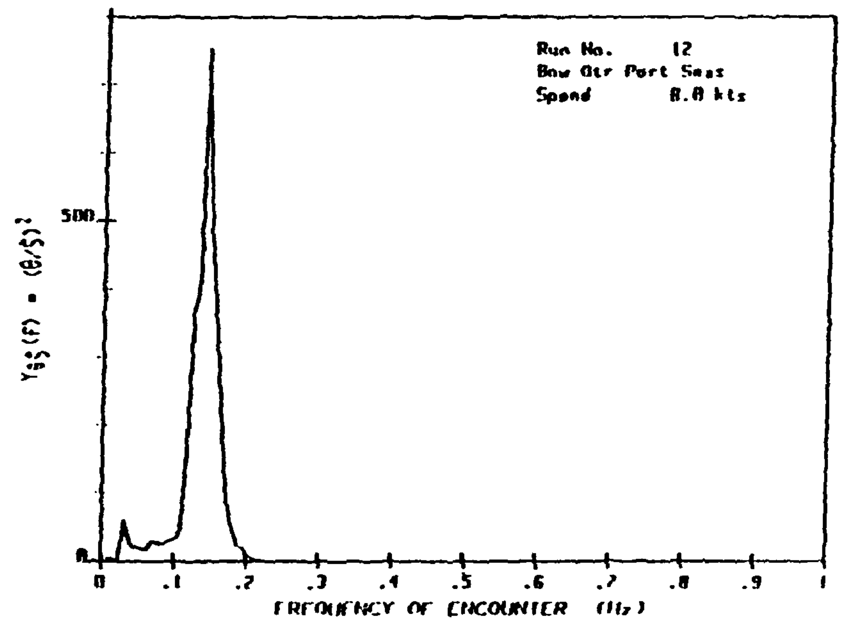
ROLL RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (WSES-1)
Tested 11/9/81

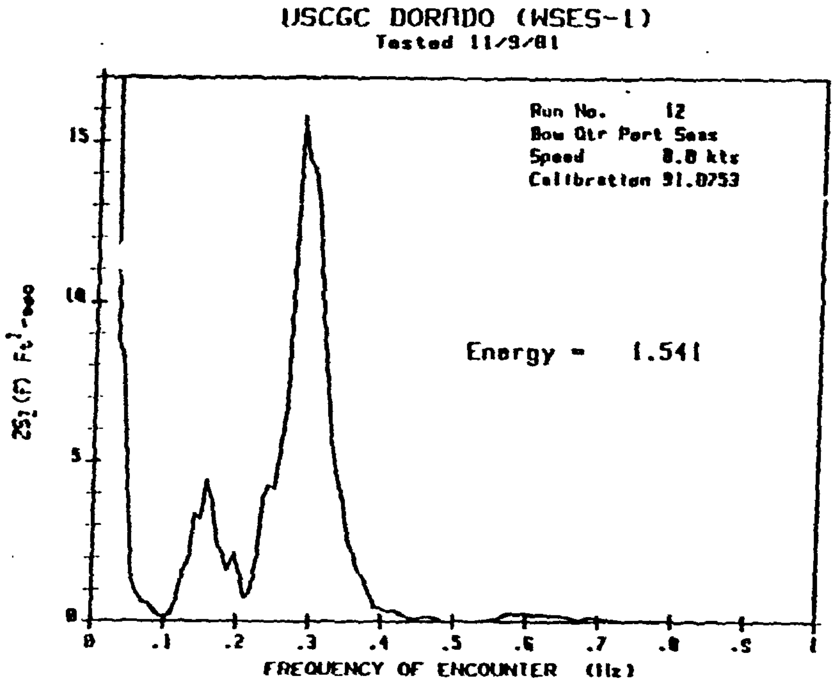


PITCH ENERGY SPECTRUM

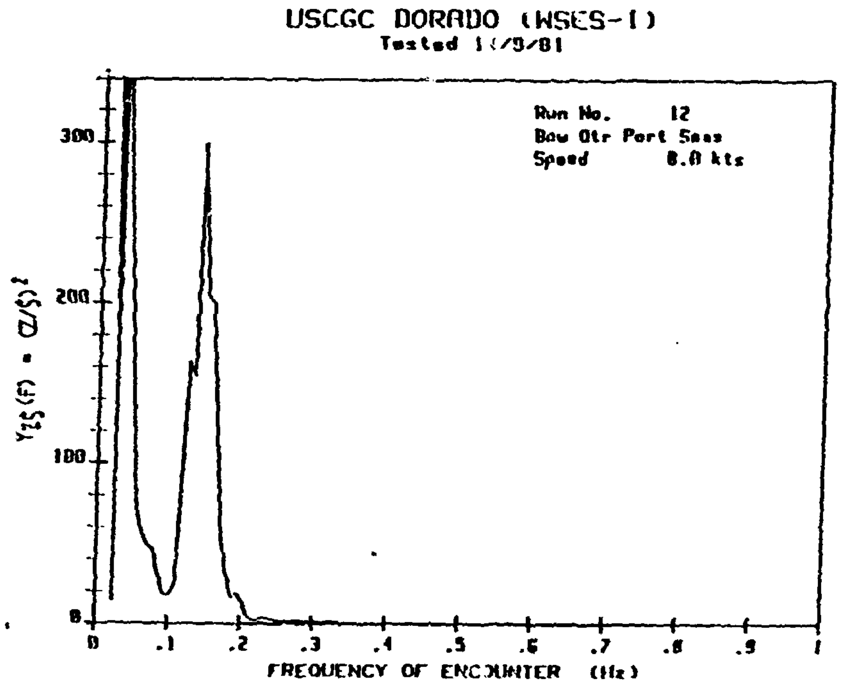
USCGC DORADO (WSES-1)
Tested 11/9/81



PITCH RESPONSE AMPLITUDE OPERATOR



HEAVE ENERGY SPECTRUM



HEAVE RESPONSE AMPLITUDE OPERATOR

USCGC DORADO (HSES-1)

Pitch Energy Spectrum
Tested 11-9-81

Run No. 1, Speed 21, SEAS-Stern Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.758750E+02
.062500	7.028504E-01
.070313	5.317668E-01
.078125	9.163208E-01
.085938	1.052612E+00
.132813	2.607544E+00
.140625	1.942222E+00
.148438	2.770997E+00
.156250	2.509888E+00
.234375	5.354920E-01
.273438	1.452103E-01
.281250	1.817245E-01
.312500	1.278076E-01
.359375	5.219269E-02
.375000	2.373123E-02
.390625	2.718830E-02
.421875	8.001328E-03
.445313	1.013327E-02
.468750	4.336595E-03
.492188	3.173470E-03
.500000	3.981352E-03
.523438	2.458573E-03
.531250	2.744914E-03
.539063	2.117754E-03
546875	2.644181E-03
.570313	1.626757E-03
.578125	1.908302E-03
.585938	1.475811E-03
.609375	1.953960E-03
.656250	2.270813E-03
.687500	8.842946E-04
.703125	1.213372E-03
.710938	6.733536E-04
.726563	1.223303E-03
.742188	8.411109E-04
.773438	1.494837E-02
.781250	1.791538E-03
.835938	4.438310E-04
.859375	6.684958E-04
.867188	5.267560E-04
.882813	8.062720E-04
.898438	5.856661E-0-
.906250	5.752742E-04
.921875	3.624261E-04
.937500	6.113648E-04
.953125	3.226698E-04
.960938	4.189269E-04
.968750	3.140419E-04
.992188	4.496426E-04

USCGC DORADO (HSES-1)

Heave Energy Spectrum
Tested 11-9/81

Run No. 1, Speed 21, SEAS-Stern Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.032644E+07
.046875	1.842397E-02
.078125	1.065772E-01
.085938	1.340831E-01
.093750	1.001503E-01
.132813	5.165758E-01
.140625	4.834450E-01
.156250	3.210815E-01
.164063	6.875267E-01
.179688	3.987630E-01
.195313	6.059209E-01
.203125	6.982319E-01
.218750	3.866262E-01
.226563	4.425874E-01
.234375	4.103930E-01
.257813	2.154238E-01
.265625	2.348202E-01
.273438	2.119990E-01
.281250	2.737470E-01
.289063	2.430339E-01
.296875	2.437602E-01
.304688	2.372405E-01
.312500	2.729493E-01
.335938	8.247415E-02
.351563	1.299913E-01
.390625	5.635990E-02
.414063	2.395511E-02
.468750	2.810519E-02
.625000	8.826520E-03
.781250	3.024438E-03
.039375	4.873175E-03

USCGC DORADO (HSES-1)

Wave Energy Spectrum
Tested 11/9/81

Run No. 2, Speed 21 , SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.008235	4.255435E+01
.027239	9.743217E-03
.038009	1.309918E-02
.120368	5.566944E-03
.172953	3.190813E-03
.254895	1.273128E-02
.325222	2.692014E-02
.376331	5.782009E-02
.430819	3.197512E-02
.614561	1.923095E+00
.648142	2.765739E+00
.867368	4.244545E-01
.947202	4.998358E-01
.988387	3.264766E-01
1.117009	2.288723E-01
1.206982	2.076682E-01
1.348277	1.005666E-01
1.446698	1.849794E-01
1.707536	4.329815E-02
1.931414	6.388727E-02
1.989495	4.976096E-02
2.168809	8.137823E-02
2.292576	5.896012E-02
2.419723	2.696455E-02
2.752373	3.374183E-02
2.891348	1.811817E-02
2.962102	2.422057E-02
3.106146	1.922211E-02
3.328547	1.390253E-02
3.481040	1.966722E-02
3.558553	1.598033E-02
3.796162	1.303045E-02
3.958792	1.666766E-02
4.124802	1.133984E-02
4.209074	1.033260E-02
4.330153	1.289667E-02
4.822636	7.260417E-03
5.005543	5.661251E-03
5.098264	8.135277E-03
5.970769	2.174231E-03
6.380516	1.320944E-03
6.590453	5.480061E-04
6.696637	9.540513E-04
7.020482	3.593586E-04
7.130100	5.917991E-04
7.351870	2.897742E-04
7.577020	5.575463E-04

USCGC DORADO (HSES-1)

Pitch Energy Spectrum
Tested 11/9/81

Run No. 2, Speed 21 , SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.159250E+03
.062500	7.103730E-02
.078125	9.488296E-02
.093750	5.971336E-02
.148438	2.287770E-02
.156250	3.253936E-02
.164063	5.128861E-02
.218750	6.370163E-02
.234375	1.194540E-01
.250000	8.362579E-02
.296875	3.162536E-01
.304688	3.815155E-01
.312500	2.930755E-01
.335938	3.594666E-01
.351563	4.307251E-01
.375000	1.165581E-01
.382813	1.935501E-01
.390625	1.697770E-01
.429688	8.404923E-02
.468750	6.655983E-02
.484375	6.835557E-02
.515625	3.940988E-02
.539063	6.235594E-02
.546875	5.584336E-02
.562500	5.445480E-02
.578125	2.313339E-02
.593750	4.533386E-02
.609375	2.076149E-02
.617188	2.518654E-02
.625000	2.018357E-02
.656250	4.989624E-03
.703125	1.638592E-03
.710938	1.830408E-03
.726563	1.282752E-03
.773438	2.509976E-02
.781250	3.262758E-03
.789063	1.421034E-03
.804688	2.758979E-03
.820313	1.235264E-03
.843750	1.071155E-03
.851563	1.327276E-03
.906250	1.124322E-03
.929688	5.529226E-04
.937500	6.586611E-04
.968750	1.075327E-03
.984375	4.559309E-04

USCGC DORADO (WSES-1)

Pitch Response Amplitude Operator
Tested 11-9-81

Run No. 2, Speed 21 , SEA.-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	2.871461E+01
.023438	1.033433E-01
.031250	2.963479E+01
.062500	7.407627E+00
.148438	4.146487E+00
.156250	6.146945E+00
.195313	5.617371E+00
.210938	7.863603E+00
.218750	6.333234E+00
.234375	9.059921E+00
.250000	6.526560E+00
.273438	3.921990E+01
.296875	1.436990E+01
.304688	1.538529E+01
.312500	1.188107E+01
.375000	2.050204E+00
.390625	3.549901E+00
.445313	2.794520E+00
.468750	5.620523E-01
.546875	9.259688E-02
.578125	2.172979E-02
.609375	1.129867E-02
.617188	1.266296E-02
.625000	9.237191E-03
.656250	1.859510E-03
.671875	2.493617E-03
.703125	7.094422E-04
.710938	8.285932E-04
.726563	6.280575E-04
.773438	2.170390E-02
.781250	3.131861E-03
.789063	1.532283E-03
.820313	1.733063E-03
.835938	2.278548E-03
.843750	1.811634E-03
.859375	2.502879E-03
.906250	2.315067E-03
.929688	1.119056E-03
.937500	1.326189E-03
.963750	2.628296E-03
.984375	1.327836E-03

USCGC DORADO (WSES-1)

Heave Energy Spectrum
Tested 11/9/81

Run No. 2, Speed 21 , SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.075473E+07
.054688	3.444751E-02
.156250	7.539326E-02
.234375	4.935467E-01
.242188	3.509208E-01
.265625	1.363892E+00
.273438	1.328218E+00
.281250	1.455554E+00
.296875	3.458285E-01
.304688	1.010314E+00
.312500	9.189917E-01
.351563	1.576307E+00
.375000	6.208342E-01
.382813	8.058010E-01
.390625	7.819158E-01
.414063	5.258133E-01
.445313	8.017753E-01
.468750	4.525679E-01
.476563	3.556130E-01
.484375	5.245031E-01
.500000	3.979504E-01
.515625	5.463110E-01
.531250	2.260007E-01
.546875	3.004276E-01
.554688	.2.982352E-01
.562500	3.092211E-01
.578125	1.893573E-01
.593750	2.623896E-01
.601563	1.653029E-01
.617188	2.301328E-01
.625000	1.923348E-01
.648438	1.322588E-01
.664063	2.075857E-01
.695313	6.448177E-02
.703125	8.602294E-02
.781250	3.496299E-02
.859375	5.188524E-02
.937500	2.768302E-02

USCGC DORADO (WSES-1)

Heave Response Amplitude Operator
Tested 11/9/81

Run No. 2. Speed 21 , SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	2.305479E+06
.023438	6.555039E-02
.031250	9.427956E+00
.054688	3.410865E+00
.140625	1.022010E+01
.156250	1.472836E+01
.171875	3.981685E+01
.179688	2.442825E+01
.187500	3.173193E+01
.195313	2.860162E+01
.210938	3.433303E+01
.218750	3.165684E+01
.226563	4.043966E+01
.234375	3.753043E+01
.242188	2.699042E+01
.265625	8.820663E+01
.273438	7.620128E+01
.281250	7.621896E+01
.296875	3.883503E+01
.304688	4.353644E+01
.312500	3.312561E+01
.328125	3.967203E+01
.335938	3.759695E+01
.351563	3.986673E+01
.375000	1.096286E+01
.390625	1.628313E+01
.398438	1.768563E+01
.414063	1.440019E+01
.429688	1.695194E+01
.453750	3.884508E+00
.476563	2.243963E+00
.625000	8.899364E-02
.703125	3.691678E-02
.937500	5.630781E-02

USCGC DORADO (WSES-1)

Wave Energy Spectrum
Tested 11/9/81

Run No. 3. Speed 21 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	4.965038E+01
.023438	1.026316E-02
.062500	1.000786E-02
.078125	1.823384E-02
.085938	1.973629E-02
.109375	1.370096E-02
.117188	2.035808E-02
.125000	1.622466E-02
.156250	3.759918E-01
.179688	1.666488E-01
.273438	4.009277E+00
.289063	3.502137E+00
.312500	3.103027E+00
.328125	1.429748E+00
.335938	2.105835E+00
.343750	1.292419E+00
.351563	1.478760E+00
.367188	1.052856E+00
.382813	1.299255E+00
.390625	8.153361E-01
.414063	1.178772E+00
.437500	4.815827E-01
.445313	9.262636E-01
.546875	2.955018E-01
.562500	2.151107E-01
.593750	2.825928E-01
.609375	2.335739E-01
.625000	2.880554E-01
.656250	1.484299E-01
.671875	1.692123E-01
.695313	2.839966E-01
.710938	1.633453E-01
.718750	1.136513E-01
.726563	1.559219E-01
.750000	1.371221E-01
.765625	1.046372E-01
.773438	1.339951E-01
.781250	1.141052E-01
.835938	2.859688E-02
.843750	3.825950E-02
.859375	2.524662E-02
.906250	9.445739E-03
.914063	1.019573E-02
.937500	5.817651E-03
.945313	7.534266E-03
.960938	3.831397E-03

USCGC DORADO (WSES-1)

Roll Energy Spectrum
Tested 11/9/81

Run No. 3, Speed 21 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	7.112891E+01
.039063	2.152954E+00
.078125	7.098632E+00
.085938	5.824462E+00
.109375	5.635254E+00
.156250	1.710645E+01
.164063	1.136523E+01
.195313	2.196192E+01
.203125	2.574707E+01
.210938	1.892187E+01
.226563	4.325538E+01
.234375	3.329493E+01
.242188	3.020507E+01
.250000	3.886914E+01
.312500	9.450195E+00
.320313	9.141602E+00
.328125	1.133984E+01
.375000	2.395374E+00
.390625	1.786742E+00
.437500	3.354493E-01
.445313	4.140168E-01
.468750	1.318923E-01
.492188	7.779312E-02
.515625	9.842301E-02
.546875	2.599430E-02
.562500	2.721710E-02
.609375	6.678619E-03
.617188	7.802486E-03
.625000	6.760597E-03
.640625	4.127026E-03
.648438	5.151034E-03
.656250	3.913165E-03
.664063	4.471302E-03
.671875	2.418518E-03
.703125	2.187179E-03
.726563	3.295779E-03
.742188	2.540946E-03
.773438	7.643938E-03
.781250	2.034059E-03
.789063	1.569219E-03
.796875	2.382278E-03
.812500	1.820504E-03
.843750	1.705777E-03
.851563	2.271171E-03
.859375	1.509011E-03
.867188	3.053184E-04
.906250	1.935422E-03
.914063	1.571119E-03
.937500	1.024127E-03
.945313	9.353976E-04
.960938	1.620054E-03
.968750	7.386506E-04

USCGC DORADO (WSES-1)

Roll Response Amplitude Operator
Tested 11/9/81

Run No. 3, Speed 21 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.023438	3.301536E+02
.039063	1.191142E+02
.078125	3.727704E+02
.085938	2.912055E+02
.101563	5.247361E+02
.117188	3.236008E+02
.125000	4.889023E+02
.156250	4.590721E+01
.164063	4.298493E+01
.179688	1.638867E+02
.257813	7.635548E+00
.281250	6.645503E+00
.289063	5.967008E+00
.296875	9.963952E+00
.312500	3.030685E+00
.328125	8.011954E+00
.359375	1.863381E+00
.382813	1.660450E+00
.390625	2.190516E+00
.414063	4.445195E-01
.429688	8.497915E-01
.453125	4.958353E-01
.468750	2.927547E-01
.492188	1.675323E-01
.546875	3.327646E-02
.562500	1.263798E-01
.585938	6.411660E-02
.625000	2.369822E-02
.632813	2.697733E-02
.640625	2.397110E-02
.648438	3.072788E-02
.664063	2.655943E-02
.687500	1.351948E-02
.695313	1.220272E-02
.703125	2.096155E-02
.710938	1.535717E-02
.742188	1.894967E-02
.750000	1.449831E-02
.773438	1.455545E-01
.781250	2.710761E-02
.789063	1.447085E-02
.812500	2.448596E-02
.828125	7.770876E-02
.843750	4.422113E-02
.859375	5.893734E-02
.867188	4.165461E-02
.906250	2.289196E-01
.914063	1.563874E-01
.929688	2.462985E-01
.937500	1.718680E-01
.945313	1.316889E-01
.960938	4.223393E-01

USCGC DORADO (USES-1)

Heave Energy Spectrum
Tested 11/9/81

Run No. 3, Speed 21 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.117306E+07
.054688	5.344119E-02
.078125	1.448260E-01
.093750	3.232251E-01
.109375	2.008008E-01
.125000	5.014359E-01
.132813	[illegible].887914E-01
.148438	[illegible].042665E-01
.156250	6.315160E-01
.164063	4.469706E-01
.179688	1.646517E+00
.210938	7.488942E-01
.226563	1.696437E+00
.234375	1.256684E+00
.242188	1.035142E+00
.250000	1.604269E+00
.257813	1.212970E+00
.273438	1.377141E+00
.281250	1.323274E+00
.296875	2.146409E+00
.312500	1.322558E+00
.320313	1.158292E+00
.328125	1.316658E+00
.351563	6.275309E-01
.375000	9.253473E-01
.390625	7.862117E-01
.437500	2.756285E-01
.445313	2.782667E-01
.468750	1.928057E-01
.492188	1.334866E-01
.507813	2.344776E-01
.531250	6.559363E-02
.625000	3.994073E-02
.859375	1.025144E-02

USCGC DORADO (USES-1)

Heave Response Amplitude Operator
Tested 11/9/81

Run No. 3, Speed 21 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.862902E+06
.046875	4.020370E+00
.062500	5.753572E+00
.070313	5.404198E+00
.078125	7.870894E+00
.101563	2.388052E+01
.117188	1.444278E+01
.125000	3.069073E+01
.156250	1.676403E+00
.179688	9.944352E+00
.218750	3.713419E-01
.234375	1.899238E-01
.453750	3.091836E-01
.546875	2.419095E-01
.960938	2.391962E+00

USCGC DORADO (WSES-1)

Heave Energy Spectrum
Tested 11/9/81

Run No. 5. Speed 21 , SEAS-Aft Qtr Stbd Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.195328E+07
.046875	4.397301E-02
.078125	2.933565E-01
.101563	3.986335E-01
.117188	3.355843E-01
.132813	5.566750E-01
.140625	5.059610E-01
.156250	1.022711E+00
.164063	9.476747E-01
.179688	1.033275E+00
.195313	9.176862E-01
.218750	1.388772E+00
.226563	1.161278E+00
.234375	1.182418E+00
.250000	9.526565E-01
.257813	1.299870E+00
.265625	1.074795E+00
.273438	1.527427E+00
.289063	1.182142E+00
.296875	1.617771E+00
.312500	9.383882E-01
.328125	1.891214E+00
.335938	1.252788E+00
.367188	2.115957E+00
.390625	7.558966E-01
.398438	8.782729E-01
.406250	7.497613E-01
.414063	7.439839E-01
.429688	4.307239E-01
.437500	4.971879E-01
.445313	3.649933E-01
.468750	4.545380E-01
.500000	1.521920E-01
.515625	2.349902E-01
.531250	2.425332E-01
.546875	1.595119E-01
.609375	5.102280E-02
.625000	5.380907E-02
.703125	1.840512E-02
.937500	9.539760E-03

USCGC DORADO (WSES-1)

Roll Energy Spectrum
Tested 11/9/81

Run No. 6. Speed 21 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	2.118760E+02
.046875	2.709862E+00
.078125	2.257812E+00
.101563	3.893432E+00
.117188	2.392944E+00
.132813	5.120117E+00
.140625	4.602051E+00
.156250	7.784667E+00
.164063	5.498534E+00
.171875	6.940918E+00
.187500	3.687256E+00
.218750	1.356250E+01
.226563	1.134277E+01
.234375	1.647461E+01
.265625	2.906542E+01
.312500	1.179692E+01
.320313	1.057715E+01
.328125	1.639453E+01
.382813	3.270019E+00
.390625	4.368408E+00
.406250	1.995117E+00
.414063	2.235107E+00
.429688	2.189086E+00
.468750	7.271728E-01
.523438	1.322861E-01
.539063	6.179619E-02
.546875	7.604599E-02
.578125	1.557064E-02
.601563	1.809597E-02
.617188	5.973578E-03
.625000	7.447720E-03
.632813	8.547732E-03
.656250	4.357675E-03
.671875	6.575107E-03
.687500	3.198027E-03
.703125	7.980824E-03
.734375	3.274917E-03
.750000	4.615546E-03
.757813	3.436326E-03
.773438	1.307583E-02
.781250	3.629565E-03
.789063	2.979142E-03
.804688	4.062786E-03
.828125	1.029730E-03
.843750	2.797485E-03
.851563	1.751960E-03
.859375	2.193923E-03
.867188	2.750277E-03
.906250	1.412570E-03
.929688	2.679826E-03
.937500	1.170802E-03
.953125	1.483398E-03
.960938	1.314621E-03

USCGC DORADO (WSES-1)

Roll Response Amplitude Operator
Tested 11/9/81

Run No. 6, Speed 21 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	4.331369E+00
.023438	7.761551E-01
.046875	1.233363E+02
.070313	1.040101E+02
.078125	1.247863E+02
.101563	2.591672E+02
.140625	4.323610E+02
.156250	6.448034E+02
.187500	7.965392E+01
.218750	5.546006E+02
.226563	4.544751E+02
.234375	6.235092E+02
.250000	3.702179E+02
.312500	4.391034E+01
.320313	3.806623E+01
.328125	5.358615E+01
.359375	3.932433E+01
.390625	7.717076E+00
.468750	1.989180E-01
.523438	4.158568E-02
.539063	2.141272E-02
.546875	2.845920E-02
.578125	7.769956E-03
.601563	1.069089E-02
.617188	3.946747E-03
.625000	5.217769E-03
.632813	6.373196E-03
.656250	4.975873E-03
.671875	8.359440E-03
.687500	4.418777E-03
.726563	8.291207E-03
.734375	7.069423E-03
.757813	7.319912E-03
.773438	2.555820E-02
.781250	6.793446E-03
.789063	5.169583E-03
.804688	8.865725E-03
.828125	1.989483E-03
.843750	5.888302E-03
.851563	3.860265E-03
.859375	4.920185E-03
.867188	6.130564E-03
.906250	2.781169E-03
.929688	5.139485E-03
.937500	4.440235E-03
.953125	3.513338E-03
.960938	4.956610E-03
.976563	3.531620E-03

USCGC DORADO (WSES-1)

Pitch Energy Spectrum
Tested 11/9/81

Run No. 6, Speed, 21 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	8.317813E+02
.023438	7.857971E-01
.039063	1.198120E+00
.062500	6.890869E-01
.085938	3.582917E-01
.109375	2.687226E-01
.117188	3.140563E-01
.132813	2.062531E-01
.156250	1.454895E+00
.171875	8.344726E-01
.234375	2.636872E-01
.312500	1.209778E+00
.320313	9.290162E-01
.382813	4.235229E-01
.390625	5.597840E-01
.406250	3.679046E-01
.460938	2.784272E-01
.468750	3.680419E-01
.546875	1.797034E-01
.625000	1.341724E-02
.656250	5.101680E-03
.664063	6.594896E-03
.679688	2.806902E-03
.687500	3.686667E-03
.695313	3.338814E-03
.734375	3.293157E-03
.742188	4.797936E-03
.757813	2.942920E-03
.773438	1.526403E-02
.781250	3.120302E-03
.789063	1.847147E-03
.796875	2.170325E-03
.820313	1.448572E-03
.859375	1.089335E-03
.882813	1.147926E-03
.898438	1.254201E-03
.906250	1.428544E-03
.921875	1.049220E-03
.937500	1.277149E-03
.945313	1.439750E-03
.976563	4.924834E-04

USCGC DORADO (USES-1)

Pitch Response Amplitude Operator
Tested 11 9 81

Run No. 6, Speed 21 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.701152E+01
.023438	2.286787E-01
.031250	6.562919E+01
.062500	3.497760E+01
.078125	1.891831E+01
.085938	2.218205E+01
.109375	1.839873E+01
.117188	2.295703E+01
.132813	1.860086E+01
.156250	1.192405E+02
.187500	4.015311E+01
.210938	1.258385E+01
.218750	2.072152E+01
.234375	9.977868E+00
.265625	2.565799E+01
.304688	4.533829E+00
.312500	5.048899E+00
.328125	3.568953E+00
.343750	2.765141E+00
.359375	3.460547E+00
.390625	9.889485E-01
.406250	4.215745E-01
.421875	6.111782E-01
.460938	8.275109E-02
.531250	3.823680E-02
.546875	6.699423E-02
.593750	1.702658E-02
.617188	8.341302E-03
.648438	5.695090E-03
.656250	5.125964E-03
.664063	7.588403E-03
.679688	3.724551E-03
.695313	4.827061E-03
.703125	7.342812E-03
.734375	7.135057E-03
.742188	1.033893E-02
.757813	6.273499E-03
.773438	2.980457E-02
.781250	5.929759E-03
.789063	3.308303E-03
.796875	3.897406E-03
.820313	2.698106E-03
.859375	2.437942E-03
.882313	2.525010E-03
.890625	2.937509E-03
.906250	2.809520E-03
.921875	1.395236E-03
.937500	2.611046E-03
.945313	3.155159E-03
.976563	1.616602E-03
.992188	3.561973E-03

USCGC DORADO (USES-1)

Heave Energy Spectrum
Tested 11-9 81

Run No. 6, Speed 21 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.204625E+07
.031250	1.158725E-01
.156250	1.816373E+00
.164063	2.005631E+00
.171875	1.926567E+00
.179688	2.485242E+00
.187500	2.312182E+00
.195313	2.591957E+00
.226563	8.632177E-01
.234375	1.032237E+00
.273438	3.752771E+00
.289063	3.307704E+00
.296875	3.421765E+00
.304688	2.881891E+00
.312500	3.219108E+00
.320313	2.949827E+00
.335938	4.748124E+00
.351563	2.863312E+00
.359375	3.441282E+00
.367188	2.797190E+00
.375000	2.804714E+00
.382813	2.419102E+00
.390625	2.325970E+00
.406250	2.074761E+00
.429688	3.963613E+00
.453125	1.444039E+00
.468750	2.083304E+00
.515625	6.708631E-01
.523438	6.731121E-01
.531250	5.039067E-01
.546875	6.985785E-01
.578125	1.250603E-01
.625000	9.081702E-02
.703125	8.099440E-02
.781250	4.581237E-02
.937500	3.557323E-02

USCGC DORADO (WSES-1)

Heave Response Amplitude Operator
Tested 11 9-81

Run No. 6, Speed 21 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.915522E+06
.023438	3.634952E-02
.062500	9.067356E+00
.078125	7.086932E+00
.156250	1.402404E+02
.187500	5.968883E+01
.195313	6.019637E+01
.210938	3.977365E+01
.218750	5.671688E+01
.226563	3.809627E+01
.234375	4.063877E+01
.250000	6.730330E+01
.257813	6.595817E+01
.265625	6.598220E+01
.312500	1.360863E+01
.320313	1.065459E+01
.353375	1.644070E+01
.390625	4.935648E+00
.406250	2.362507E+00
.625000	6.461153E-02
.703125	1.300147E-01
.781250	8.546469E-02
.937500	7.308741E-02

USCGC DORADO (WSES-1)

Pitch Energy Spectrum
Tested 11 9 81

Run No. 7, Speed 3 , SEAS-Stern Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	3.896406E+02
.054688	2.381653E-02
.078125	1.452560E-01
.117188	3.111816E+00
.132813	1.277246E+01
.156250	7.073242E+00
.171875	3.166504E+00
.179688	4.037598E+00
.234375	1.660766E-01
.242188	1.285400E-01
.257813	2.071338E-01
.289063	1.171265E-01
.312500	6.377462E-02
.328125	6.571960E-02
.351563	2.151870E-02
.359375	3.263354E-02
.390625	9.534835E-03
.398438	1.447248E-02
.421875	4.817248E-03
.445313	8.101941E-03
.460938	3.190160E-03
.468750	3.654122E-03
.492188	1.744747E-03
.500000	3.257632E-03
.531250	1.156628E-03
.539063	2.047181E-03
.546875	1.764239E-03
.562500	3.924002E-04
.601563	1.153237E-03
.617188	5.673766E-04
.625000	8.386755E-04
.648438	1.251639E-03
.664063	6.136000E-04
.687500	7.392168E-04
.695313	9.854435E-04
.703125	7.603162E-04
.773438	1.756573E-02
.781250	2.292275E-03
.796875	6.374717E-04
.804688	7.441938E-04
.828125	5.009770E-04
.859375	2.449453E-04
.898438	4.536429E-04
.914063	2.759249E-04
.929688	4.395693E-04
.937500	3.679203E-04
.945313	3.200472E-04
.953125	4.197357E-04
.968750	3.397315E-04
.976563	3.946125E-04
.992188	3.662706E-04

USCGC DORADO (WSES-1)

Heave Energy Spectrum
Tested 11/9/81

Run No. 7, Speed 8 , SEAS-Stern Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.227533E+07
.062500	1.273549E-02
.078125	1.279477E-02
.132813	3.256301E+00
.148438	2.547484E+00
.156250	3.173127E+00
.164063	2.963701E+00
.179688	3.920306E+00
.218750	7.435923E-01
.234375	1.215967E+00
.250000	5.305757E-01
.257813	6.629838E-01
.296875	2.229820E-01
.312500	2.003547E-01
.421875	9.370189E-03
.468750	4.745032E-03
.546875	2.460092E-03
.781250	9.691715E-04
.859375	2.720292E-04

USCGC DORADO (WSES-1)

Wave Energy Spectrum
Tested 11-9-81

Run No. 8, Speed 8 , SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007973	5.477657E+01
.024985	2.080429E-02
.094218	7.950049E-03
.105409	7.779138E-03
.153396	1.814391E-02
.166197	1.281164E-02
.192765	5.261555E-02
.206532	4.286220E-02
.220620	6.357207E-02
.361901	1.051267E+01
.379208	7.339510E+00
.655302	4.641222E-01
.677437	3.470992E-01
.699993	4.114257E-01
.792939	3.105669E-01
.817005	2.260100E-01
.841392	2.987620E-01
.891134	2.438466E-01
.916487	2.763171E-01
1.048032	8.174349E-02
1.102972	1.639472E-01
1.305229	9.146725E-02
1.588445	8.626474E-02
1.654923	3.871750E-02
1.722688	4.048427E-02
1.791740	2.727691E-02
1.826749	3.721369E-02
2.006621	3.252408E-02
2.080623	1.325914E-02
2.156312	2.426291E-02
2.194540	2.171107E-02
2.271960	3.777359E-02
2.390504	1.539736E-02
2.471143	8.769139E-03
2.636283	6.639470E-03
2.806573	4.166207E-03
2.849950	5.775927E-03
3.071653	1.959055E-03
3.162601	3.007919E-03
3.254826	1.429638E-03
3.348359	1.357569E-03
3.537754	7.133036E-04

USCGC DORADO (WSES-1)

Pitch Energy Spectrum
Tested 11-9-81

Run No. 8, Speed 8, SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.763222E+01
.070313	4.749909E-01
.078125	3.118438E-01
.085938	2.536926E-01
.117188	2.452317E-01
.132813	3.973541E-01
.148438	2.624512E-01
.195313	2.855072E-01
.234375	1.867554E+00
.304688	1.519141E+01
.312500	5.838379E+00
.328125	8.445312E+00
.343750	4.347168E+00
.351563	5.373779E+00
.390625	8.070678E-01
.468750	4.923970E-02
.492188	2.854634E-02
.515625	2.355862E-02
.523438	3.015805E-02
.546875	2.188683E-02
.562500	2.742005E-02
.570313	2.136040E-02
.601563	4.865074E-02
.609375	3.112411E-02
.640625	5.532264E-02
.671875	6.204987E-02
.695313	3.410530E-02
.703125	2.610397E-02
.773438	2.463054E-02
.781250	1.360083E-02
.828125	7.915019E-03
.851563	5.790234E-03
.859375	4.172086E-03
.867188	4.090070E-03
.906250	5.960464E-03
.914063	7.599115E-03
.937500	3.004670E-03
.945313	2.992630E-03
.960938	5.100965E-03
.976563	4.294872E-03

USCGC DORADO (WSES-1)

Pitch Response Amplitude Operator
Tested 11-9-81

Run No. 8, Speed 8, SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.812703E+00
.023438	9.543349E-01
.031250	4.920679E+01
.046875	1.695827E+01
.070313	2.458168E+01
.101563	4.163087E+01
.117188	1.866875E+01
.132813	2.902873E+01
.148438	1.767556E+01
.156250	2.309702E+01
.164063	2.607776E+01
.195313	5.604876E+00
.218750	2.313127E+01
.234375	1.160831E+01
.296875	5.954221E+00
.328125	1.614192E+00
.351563	6.891765E-01
.398438	1.400934E-01
.421875	6.346444E-02
.437500	8.348453E-02
.453125	6.089840E-02
.492188	2.890015E-02
.507813	3.939713E-02
.515625	2.950160E-02
.539063	3.271609E-02
.546875	4.204651E-02
.562500	5.679650E-02
.601563	9.525980E-02
.609375	6.237446E-02
.625000	1.180622E-01
.640625	1.295764E-01
.671875	1.633817E-01
.703125	6.284385E-02
.773438	7.704776E-02
.781250	4.298219E-02
.828125	3.005673E-02
.851563	2.031563E-02
.906250	2.193172E-02
.914063	2.693036E-02
.976563	2.917345E-02

USCGC DORADO (HSES-1)

Heave Energy Spectrum
Tested 11-9-81

Run No. 8, Speed 8 , SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.235833E+07
.062500	2.692117E-02
.234375	3.681449E+00
.257813	7.552659E+00
.281250	6.151199E+00
.304688	1.478423E+01
.312500	6.157290E+00
.328125	8.538552E+00
.343750	5.013933E+00
.351563	5.871724E+00
.390625	9.305054E-01
.421875	4.798162E-01
.468750	1.149362E-01
.625000	2.347168E-01
.859375	2.896656E-02
.937500	1.798476E-02

USCGC DORADO (HSES-1)

Heave Response Amplitude Operator
Tested 11-9-81

Run No. 8, Speed 8 , SEAS-Head Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.730065E+06
.023438	2.324771E-01
.031250	5.599593E+00
.062500	1.382227E+00
.101563	6.639485E+00
.117188	3.181845E+00
.132813	7.786489E+00
.140625	7.491049E+00
.156250	1.313285E+01
.164063	1.563230E+01
.171875	1.017142E+01
.218750	4.184573E+01
.234375	2.196854E+01
.242188	1.829335E+01
.250000	1.977252E+01
.281250	4.474895E+00
.296875	6.249330E+00
.312500	1.396045E+00
.468750	7.390884E-02
.546875	1.184621E-01
.625000	5.315444E-01
.859375	1.089955E-01
.937500	6.923905E-02

USCGC DORADO (USES-1)

Roll Energy Spectrum
Tested 11/9/81

Run No. 9, Speed 8 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.067813	4.010352E+01
.078125	5.146789E-02
.085938	5.854797E-02
.101563	4.969328E-02
.156250	1.633203E+01
.187500	2.752832E+01
.195313	2.344531E+01
.210938	3.693165E+01
.234375	2.376074E+01
.250000	4.934374E+01
.265625	2.603418E+01
.273438	3.241916E+01
.312500	9.869165E+00
.390625	4.479675E-01
.414063	3.153992E-01
.429688	4.144134E-01
.460938	8.074570E-02
.468750	9.973144E-02
.476563	1.220093E-01
.500000	4.230830E-02
.507813	5.315205E-02
.523438	3.017330E-02
.531250	3.797531E-02
.546875	2.203560E-02
.585938	1.486731E-02
.593750	1.697922E-02
.617188	1.167489E-02
.625000	8.549690E-03
.640625	9.019351E-03
.671875	4.473666E-03
.687500	4.086733E-03
.773438	2.485173E-02
.781250	4.450322E-03
.789063	2.359152E-03
.796875	2.639533E-03
.804688	1.854778E-03
.820313	2.110005E-03
.823125	2.763782E-03
.859375	2.547741E-03
.875000	1.375675E-03
.921875	1.077831E-03
.937500	1.373275E-03
.945313	9.730757E-04
.968750	1.106858E-03
.984375	1.843632E-03

USCGC DORADO (USES-1)

Roll Response Amplitude Operator
Tested 11/9/81

Run No. 9, Speed 8 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.023438	5.823648E+01
.046875	9.725640E+00
.062500	2.026593E+00
.078125	3.437014E+00
.085938	3.550724E+00
.101563	1.498902E+00
.132813	1.101394E+02
.140625	6.066141E+01
.156250	9.411617E+01
.203125	2.144491E+00
.210938	2.718178E+00
.234375	1.129937E+00
.265625	5.624557E+00
.273438	7.231291E+00
.312500	4.520242E+00
.320313	5.431760E+00
.351563	1.833306E+00
.382813	4.506620E-01
.390625	5.166843E-01
.398438	1.000120E+00
.414063	4.817284E-01
.468750	2.585136E-01
.476563	3.812885E-01
.500000	9.629945E-02
.507813	1.585154E-01
.515625	9.336180E-02
.531250	1.444842E-01
.570313	1.237017E-01
.585938	4.639290E-02
.593750	9.180726E-02
.617188	4.731172E-02
.625000	3.974553E-02
.632813	3.670050E-02
.640625	6.296937E-02
.664063	1.833395E-02
.671875	2.174175E-02
.679688	1.856331E-02
.734375	5.709683E-02
.750000	2.152647E-02
.773438	2.328276E-01
.781250	5.757700E-02
.789063	3.914905E-02
.796875	5.602280E-02
.828125	1.063750E-01
.843750	7.138323E-02
.859375	1.393153E-01
.875000	6.809383E-02
.890625	1.831600E-01
.898438	1.057066E-01
.906250	1.501606E-01
.921875	1.139244E-01
.937500	3.582131E-01
.945313	2.012414E-01
.960938	3.935443E-01

USCGC DORADO (WSES-1)

Heave Energy Spectrum
Tested 11/9/81

Run No. 9, Speed 8 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.271358E+07
.078125	1.188496E-02
.132813	2.460719E+00
.140625	2.134117E+00
.156250	6.561560E+00
.164063	6.793344E+00
.203125	3.769015E+00
.210938	5.301592E+00
.218750	3.925421E+00
.226563	3.950442E+00
.234375	3.574274E+00
.250000	8.609532E+00
.265625	5.151604E+00
.273438	7.323577E+00
.289063	3.732115E+00
.296875	6.871879E+00
.312500	2.549748E+00
.320313	1.780504E+00
.328125	2.363411E+00
.375000	5.604328E-01
.390625	5.279643E-01
.468750	9.053470E-02
.781250	1.826379E-02
.859375	7.763161E-03
.937500	5.644784E-03

USCGC DORADO (WSES-1)

Heave Response Amplitude Operator
Tested 11/9/81

Run No. 9, Speed 8 , SEAS-Stbd Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.604399E+06
.039063	1.382115E+00
.078125	9.388435E-01
.132813	5.156378E+01
.140625	2.377211E+01
.148438	4.452092E+01
.156250	3.211969E+01
.203125	3.038060E-01
.312500	1.120639E+00
.390625	5.820325E-01
.468750	2.346841E-01
.937500	1.080839E+00

USCGC DORADO (WSES-1)

Wave Energy Spectrum
Tested 11/9/81

Run No. 10, Speed 8 , SEAS-Port Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	5.772266E+01
.023438	1.232576E-02
.078125	1.332283E-02
.101563	1.273441E-02
.156250	2.043381E-01
.234375	1.323144E+01
.296875	3.070312E+00
.312500	1.678467E+00
.328125	1.541077E+00
.367188	8.848571E-01
.382813	7.068482E-01
.390625	8.225098E-01
.414063	9.561768E-01
.437500	7.032165E-01
.460938	5.982405E-01
.468750	4.296723E-01
.492188	3.042298E-01
.507813	5.317382E-01
.531250	2.127762E-01
.546375	3.106842E-01
.578125	1.837845E-01
.585938	2.661590E-01
.609375	2.537536E-01
.625000	1.810456E-01
.664063	1.524811E-01
.679688	1.126900E-01
.687500	9.273530E-02
.703125	1.603013E-01
.710938	1.210239E-01
.718750	1.423367E-01
.750000	1.109351E-01
.757813	9.832763E-02
.789063	9.388733E-02
.851563	2.804351E-02
.859375	1.995754E-02
.882813	2.261162E-02
.906250	1.359034E-02
.921875	1.555920E-02
.937500	8.955002E-03
.945313	1.182127E-02
.984375	4.486083E-03

USCGC DORADO (WSES-1)

Roll Energy Spectrum
Tested 11/9/81

Run No. 10, Speed 8 , SEAS-Port Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	3.642392E+01
.070313	3.333474E-02
.078125	4.514694E-02
.085938	5.128473E-02
.093750	4.202080E-02
.156250	3.067016E+00
.234375	3.874610E+01
.242188	3.363282E+01
.273438	1.948339E+01
.289063	3.122461E+01
.312500	1.317322E+01
.328125	3.472991E+00
.335938	4.071290E+00
.390625	7.266846E-01
.468750	1.053352E-01
.492188	2.530098E-02
.546875	1.694630E-02
.554688	2.251053E-02
.593750	1.094866E-02
.617188	1.012039E-02
.640625	6.029130E-03
.648438	8.254528E-03
.656250	5.704403E-03
.695313	4.275083E-03
.703125	4.984482E-03
.710938	3.790379E-03
.718750	4.303462E-03
.757813	2.873666E-03
.773438	1.829624E-02
.781250	4.322530E-03
.843750	1.521707E-03
.914063	1.163304E-03
.921875	1.547754E-03
.937500	1.019001E-03
.945313	6.181598E-04
.960938	1.573861E-03

USCGC DORADO (WSES-1)

Roll Response Amplitude Operator
Tested 11/9/81

Run No. 10, Speed 8 , SEAS-Port Beam Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.023438	7.034050E+01
.039063	5.272843E+00
.046375	7.192331E+00
.070313	2.400110E+00
.078125	3.383690E+00
.093750	2.476088E+00
.125000	5.021002E+01
.140625	1.815956E+01
.148438	2.071578E+01
.156250	1.500952E+01
.179688	8.755598E+00
.195313	2.642785E+00
.210938	3.457406E+00
.234375	2.928334E+00
.273438	8.285728E+00
.312500	7.351343E+00
.328125	2.253555E+00
.351563	3.898977E+00
.390625	8.834967E-01
.421875	2.539952E-01
.460938	1.957509E-01
.468750	2.451525E-01
.492188	8.316404E-02
.523438	9.839134E-02
.539063	4.793126E-02
.546875	5.454671E-02
.578125	6.797189E-02
.585938	3.739681E-02
.593750	5.383841E-02
.609375	3.594033E-02
.617188	5.498444E-02
.625000	3.449351E-02
.640625	4.892432E-02
.648438	6.971696E-02
.656250	4.457154E-02
.671875	6.577007E-02
.687500	4.961435E-02
.726563	3.342127E-02
.773438	1.746949E-01
.781250	4.900213E-02
.796875	2.221072E-02
.829125	5.999330E-02
.835938	4.851789E-02
.859375	1.367492E-01
.867188	1.639992E-01
.882813	5.703027E-02
.906250	9.616329E-02
.914063	7.595291E-02
.929688	1.353005E-01
.937500	1.137913E-01
.945313	5.229217E-02
.960938	2.217119E-01

USCGC DORADO (WSES-1)

Roll Energy Spectrum
Tested 11/9/81

Run No. 11, Speed 8 , SEAS-Aft Qtr Stbd Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.992187E+00
.078125	3.422738E-02
.156250	9.422363E+00
.171875	6.559570E+00
.234375	2.955469E+01
.242188	4.004883E+01
.312500	1.262695E+01
.390625	3.820038E-01
.398438	3.304595E-01
.406250	3.678437E-01
.460938	5.145454E-02
.500000	4.652024E-02
.531250	1.937962E-02
.546875	2.437019E-02
.554688	2.451325E-02
.585938	8.291722E-03
.593750	6.160974E-03
.617188	9.354532E-03
.648438	6.337166E-03
.656250	7.502555E-03
.695313	4.717827E-03
.703125	4.209757E-03
.710938	3.808379E-03
.718750	4.737616E-03
.757813	2.320410E-03
.773438	4.714966E-03
.781250	3.982067E-03
.812500	3.379464E-03
.859375	3.036686E-03
.875000	2.902746E-03
.882813	2.511501E-03
.898438	3.345966E-03
.937500	1.693786E-03
.968750	3.114939E-03
.984375	1.743614E-03

USCGC DORADO (WSES-1)

Pitch Energy Spectrum
Tested 11/9/81

Run No. 11, Speed 8 , SEAS-Aft Qtr Stbd Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	3.781250E+02
.078125	9.394074E-02
.117188	8.485352E+00
.148438	9.659179E+00
.156250	7.811523E+00
.210938	1.688720E+00
.226563	2.051392E+00
.234375	3.802002E+00
.265625	3.754029E+00
.273438	4.184814E+00
.312500	1.426203E+00
.359375	3.136597E-01
.367188	3.660584E-01
.382813	1.554108E-01
.390625	1.761779E-01
.437500	5.403432E-02
.468750	2.988147E-02
.531250	1.130676E-02
.539063	1.562881E-02
.546875	1.152468E-02
.554688	7.735014E-03
.609375	8.572101E-03
.625000	5.079746E-03
.695313	3.081918E-03
.703125	2.371430E-03
.757813	1.677573E-03
.773438	1.249456E-02
.781250	2.777696E-03
.789063	1.515687E-03
.796875	2.040982E-03
.828125	7.414818E-04
.859375	1.390636E-03
.906250	9.783506E-04
.921875	1.129031E-03
.937500	7.521808E-04
.945313	6.030202E-04
.976563	1.263439E-03
.992188	6.321155E-04

USCGC DORADO (WSES-1)

Heave Energy Spectrum
Tested 11/9/81

Run No. 11, Speed 8 , SEAS-Aft Qtr Stbd Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.330788E+07
.078125	8.023369E-01
.093750	4.085390E-01
.148438	3.510596E+00
.156250	3.043562E+00
.171875	2.134025E+00
.179688	2.382772E+00
.187500	2.200833E+00
.195313	3.048714E+00
.203125	2.790679E+00
.234375	6.834902E+00
.242188	8.875357E+00
.265625	5.013645E+00
.273438	5.637324E+00
.312500	2.221467E+00
.351563	4.354982E-01
.601563	1.753767E-02
.625000	1.639839E-02
.703125	1.100148E-02
.781250	5.363374E-03
.859375	3.401011E-03
.937500	2.067102E-03

USCGC DORADO (WSES-1)

Roll Energy Spectrum
Tested 11/9/81

Run No. 12, Speed 3 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.484688E+02
.078125	1.347961E-01
.101563	6.067848E-02
.156250	1.245850E+01
.164063	1.313184E+01
.187500	7.609131E+00
.195313	1.213916E+01
.210938	6.222413E+00
.234375	1.956211E+01
.273438	3.973829E+01
.312500	1.062500E+01
.390625	5.025024E-01
.421875	2.031493E-01
.468750	8.092499E-02
.476563	6.195640E-02
.484375	7.933317E-02
.507813	4.741478E-02
.539063	2.761078E-02
.546875	3.073270E-02
.554688	3.489375E-02
.585938	2.079677E-02
.609375	1.492210E-02
.664063	5.839109E-03
.671875	8.190632E-03
.695313	4.792690E-03
.703125	7.129954E-03
.718750	4.148483E-03
.742188	3.497362E-03
.773438	2.158261E-02
.781250	4.776240E-03
.796375	2.653837E-03
.812500	4.351378E-03
.835938	2.594352E-03
.843750	3.359914E-03
.875000	4.096269E-03
.914063	2.169133E-03
.929688	2.912760E-03
.937500	2.269328E-03
.968750	1.838962E-03
.984375	1.353562E-03

USCGC DORADO (WSES-1)

Roll Response Amplitude Operator
Tested 11/9/81

Run No. 12, Speed 3 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.015625	3.351356E+00
.023438	2.264233E+00
.031250	5.209133E+01
.062500	8.386681E+00
.078125	1.055173E+01
.140625	6.020356E+02
.156250	5.310286E+02
.187500	7.812535E+01
.195313	1.076839E+02
.234375	1.883339E+01
.265625	5.762229E+00
.273438	6.783057E+00
.320313	1.512110E+00
.390625	2.955252E-01
.421875	1.475264E-01
.468750	9.662912E-02
.484375	7.465192E-02
.500000	3.692154E-02
.507813	5.034363E-02
.546875	9.071023E-02
.554688	9.267595E-02
.609375	2.657795E-02
.617188	1.927734E-02
.625000	2.314663E-02
.640625	2.783425E-02
.664063	1.529641E-02
.671875	1.925059E-02
.679698	1.732664E-02
.687500	2.061401E-02
.695313	1.829744E-02
.703125	3.085054E-02
.718750	2.106631E-02
.742188	1.450411E-02
.773438	8.209497E-02
.781250	1.954930E-02
.796875	1.287666E-02
.835333	1.527734E-02
.859375	2.144096E-02
.875000	3.130951E-02
.919588	1.744109E-02
.937500	1.559661E-02
.9 5313	1.263397E-02
.968750	2.231890E-02
.983375	1.417264E-02

USCGC DORADO (WSES-1)

Pitch Energy Spectrum
Tested 11/9/81

Run No. 12, Speed 8 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	3.387187E+02
.062500	2.209701E-01
.078125	3.645173E-01
.093750	2.762451E-01
.101563	2.342224E-01
.140625	8.862304E+00
.156250	9.169434E+00
.195313	2.232789E+00
.210938	6.337891E-01
.234375	1.331970E+00
.296875	1.193799E+01
.312500	8.486328E+00
.390625	3.084411E-01
.445313	5.617333E-02
.460938	9.254837E-02
.468750	6.872558E-02
.484375	1.316368E-02
.507813	2.446842E-02
.515625	2.773530E-02
.539063	1.984214E-02
.562500	2.907843E-02
.578125	6.187433E-02
.593750	5.749512E-02
.609375	4.088734E-02
.671875	1.523179E-02
.687500	2.625560E-02
.703125	1.893520E-02
.750000	6.119251E-03
.773438	1.799584E-02
.781250	7.251501E-03
.804688	4.825830E-03
.812500	6.305218E-03
.828125	2.739549E-03
.859375	6.058931E-03
.890625	6.001949E-03
.906250	4.274606E-03
.914063	5.795717E-03
.929688	4.555941E-03
.937500	5.754709E-03
.945313	5.784750E-03
.960938	3.723382E-03
.976563	5.060672E-03
.992188	3.913403E-03

USCGC DORADO (WSES-1)

Pitch Response Amplitude Operator
Tested 11/9/81

Run No. 12, Speed 8 , SEAS-Bow Qtr Port Seas

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	5.937097E+00
.023438	1.570775E+00
.031250	6.198047E+01
.054688	2.307703E+01
.062500	1.531579E+01
.078125	2.384434E+01
.085938	2.350125E+01
.101563	2.839903E+01
.140625	7.551908E+02
.156250	3.497291E+02
.234375	1.262290E+00
.250000	1.045963E+00
.265625	8.233667E-01
.281250	1.759399E+00
.312500	1.105682E+00
.367188	2.325464E-01
.382813	3.052486E-01
.390625	1.849186E-01
.398438	2.110785E-01
.445313	4.593032E-02
.460938	1.121313E-01
.468750	8.227343E-02
.546875	1.077233E-01
.562500	7.143316E-02
.578125	1.317596E-01
.609375	7.013104E-02
.625000	9.795043E-
.632813	1.105775E-
.656250	9.348749E-02
.671875	4.433010E-02
.703125	8.252697E-02
.710938	8.282491E-02
.750000	2.437413E-02
.773438	6.934383E-02
.781250	2.396301E-02
.804688	2.525498E-02
.812500	3.577556E-02
.828125	1.631172E-02
.859375	4.725112E-02
.890625	4.310149E-02
.906250	3.031553E-02
.914063	3.480500E-02
.937500	3.865784E-02
.945313	4.511612E-02
.953125	3.572743E-02
.976563	5.681223E-02
.992188	4.223918E-02

USCGC DORADO (USES-1)

Heave Energy Spectrum
Tested 11-9-81

Run No. 12, Speed 8 , SEAS-Bow Qtr Port

FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	9.657153E+07
.078125	5.903859E-01
.101563	1.502815E-01
.140625	3.397231E+00
.148438	3.188670E+00
.156250	4.399619E+00
.187500	1.583231E+00
.195313	2.154980E+00
.210938	7.172053E-01
.234375	3.873621E+00
.242188	4.250429E+00
.250000	4.134577E+00
.281250	1.530861E+01
.312500	9.791173E+00
.390625	4.529869E-01
.445313	1.077883E-01
.468750	1.402173E-01
.546875	9.129245E-02
.625000	2.065686E-01
.703125	9.867561E-02
.859375	2.830294E-02
.937500	1.845769E-02

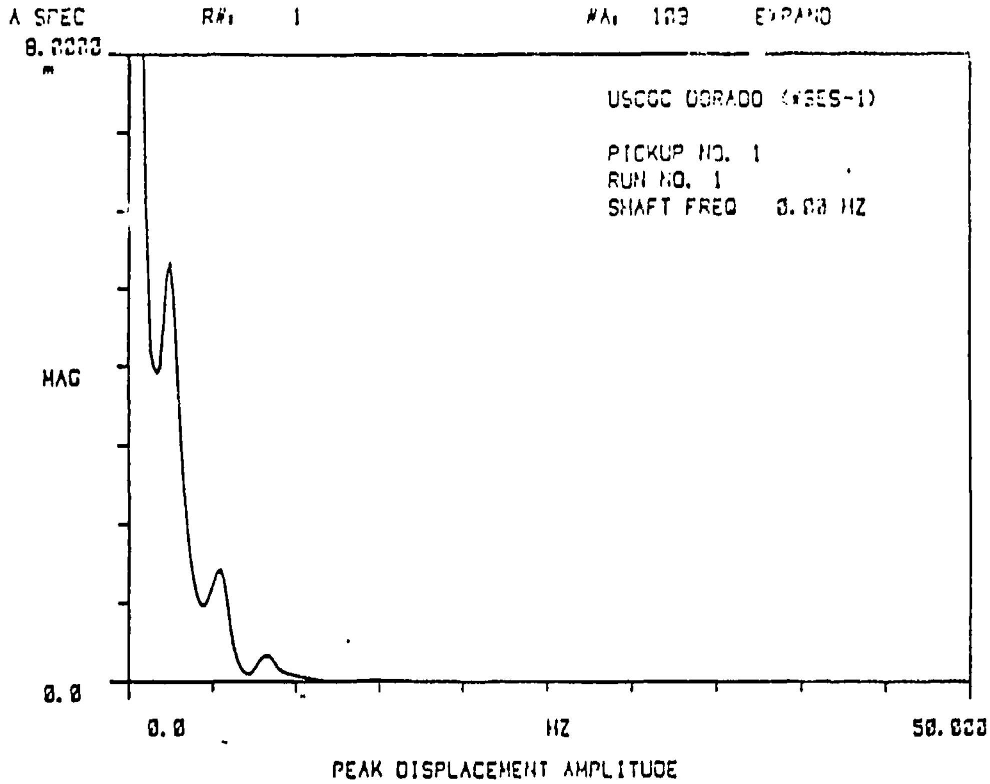
USCGC DORADO (USES-1)

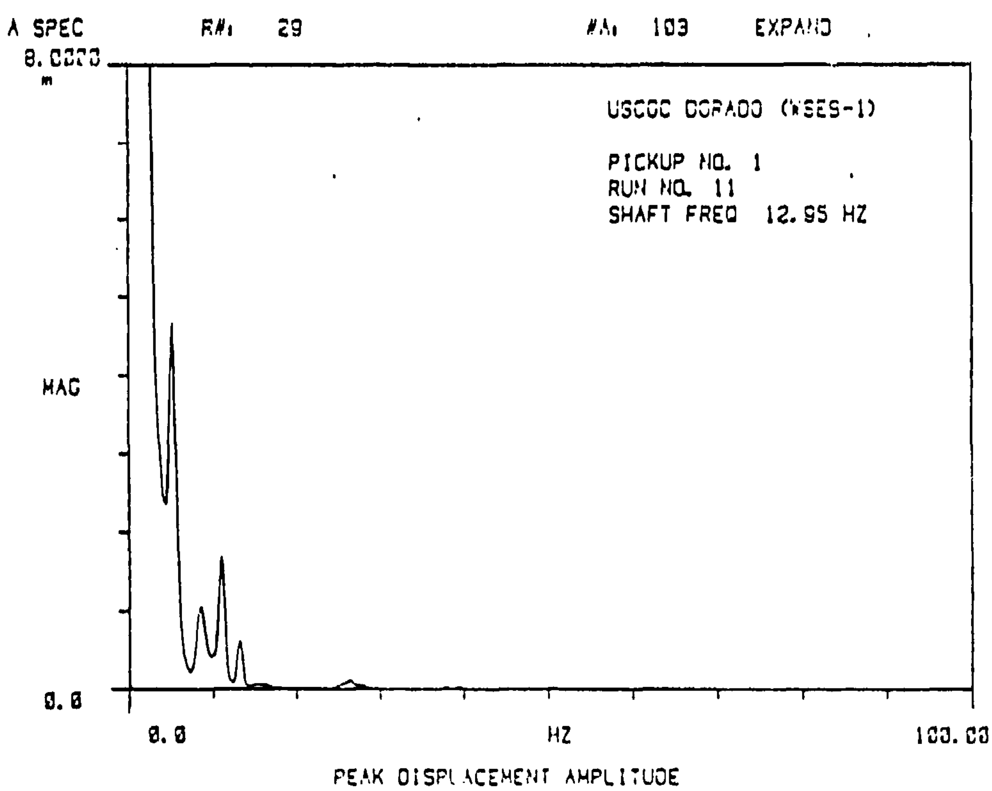
Heave Response Amplitude Operator
Tested 11-9-81

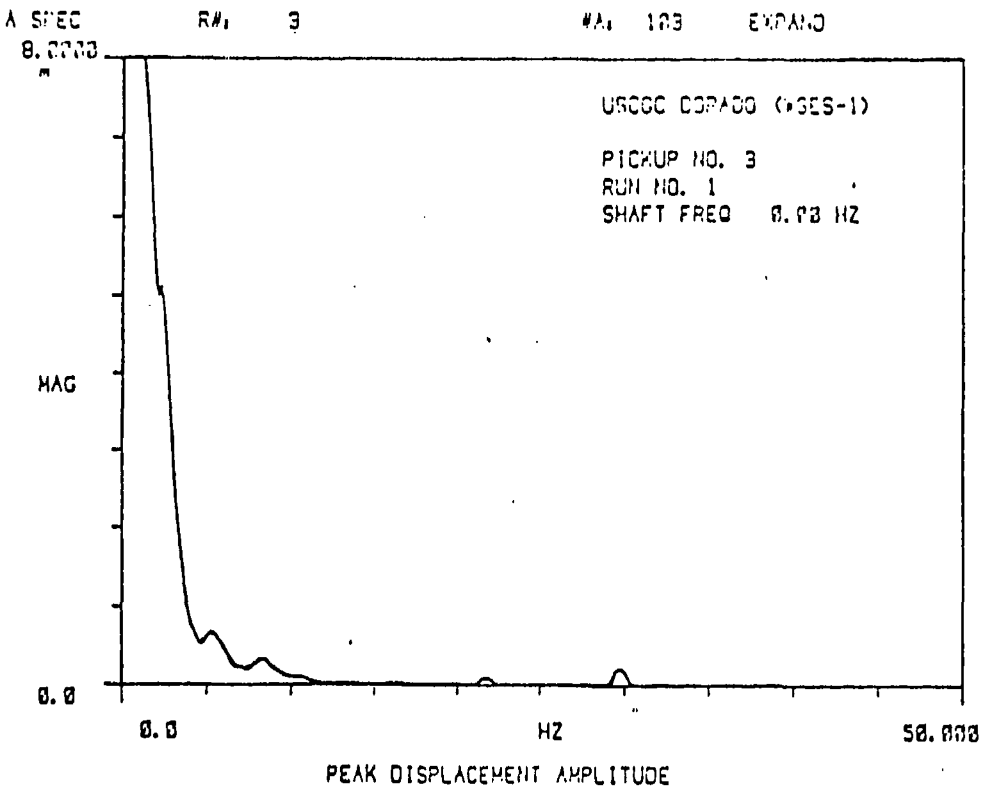
Run No. 12, Speed 8 , SEAS-Bow Qtr Port Seas

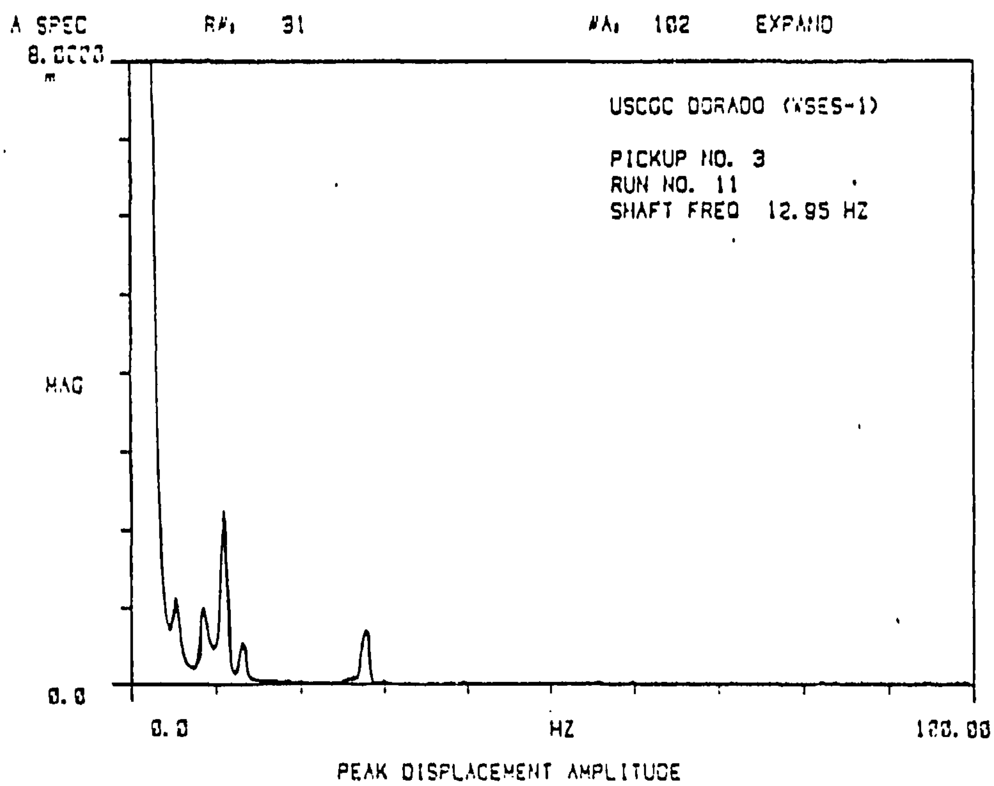
FREQUENCY OF ENCOUNTER	AMPLITUDE
.007813	1.658191E+06
.023438	1.360354E+01
.031250	4.037557E+02
.078125	4.677320E+01
.101563	1.766326E+01
.132813	1.547525E+02
.140625	2.933841E+02
.156250	1.993876E+02
.187500	1.608241E+01
.195313	1.914031E+01
.218750	2.363364E+00
.234375	3.670510E+00
.265625	1.307193E+00
.281250	2.385156E+00
.312500	1.255301E+00
.367188	3.360571E-01
.382813	4.629010E-01
.390625	2.717213E-01
.398438	3.325530E-01
.445313	9.156677E-02
.460938	2.029932E-01
.468750	1.633775E-01
.492188	3.422604E-02
.546875	2.624041E-01
.562500	2.923570E-01
.578125	5.481065E-01
.609375	3.258399E-01
.625000	4.060347E-01
.671875	2.536733E-01
.703125	4.348399E-01
.710938	4.903707E-01
.757813	2.188326E-01
.804688	1.174749E-01
.812500	1.756564E-01
.859375	2.481145E-01
.867188	1.577390E-01
.882313	2.192977E-01
.929688	7.551061E-02
.937500	1.243349E-01
.945313	1.810241E-01
.953125	1.501847E-01
.976563	2.159556E-01
.992188	1.228995E-01

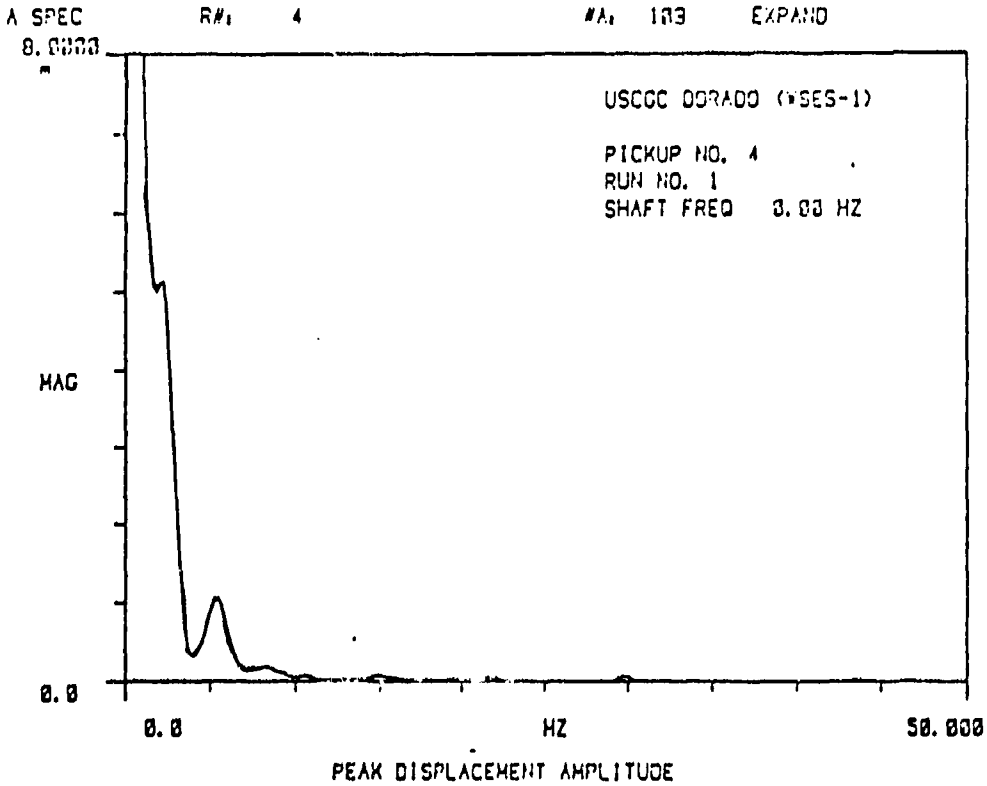
FIGURES A-50 THROUGH A-57
VIBRATION SPECTRA

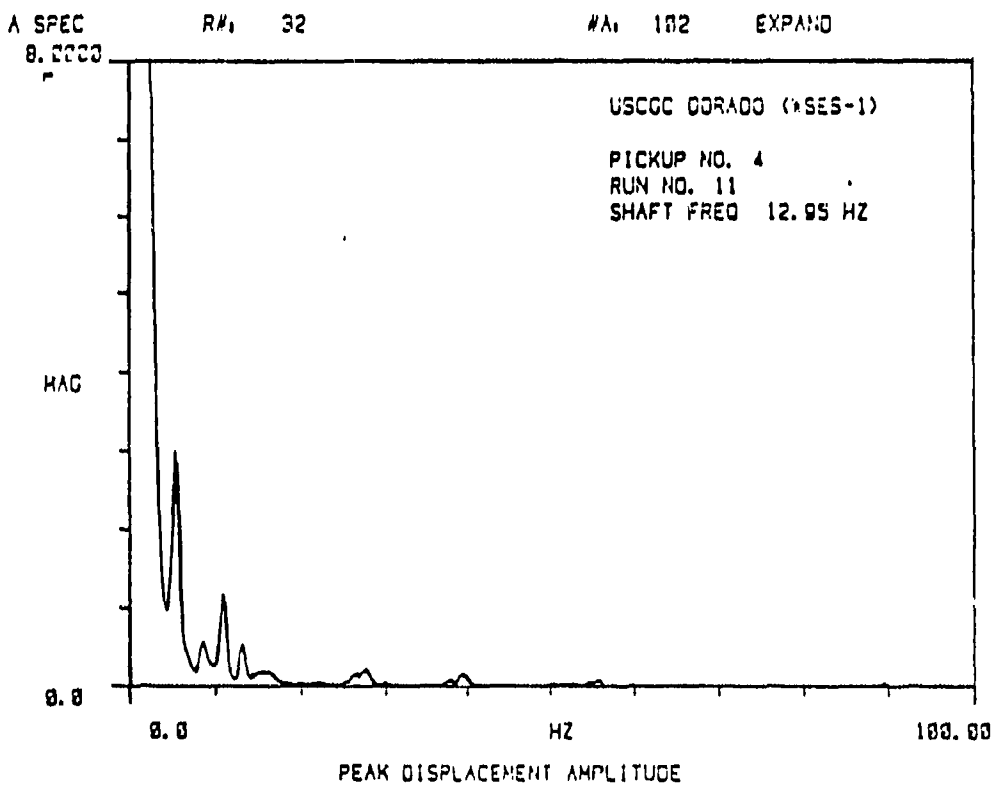

A SPEC
R#: 1
#A: 103
EXPAND
8.0000
m
USCGC DORADO (WSES-1)
PICKUP NO. 1
RUN NO. 1
SHAFT FREQ 0.00 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE

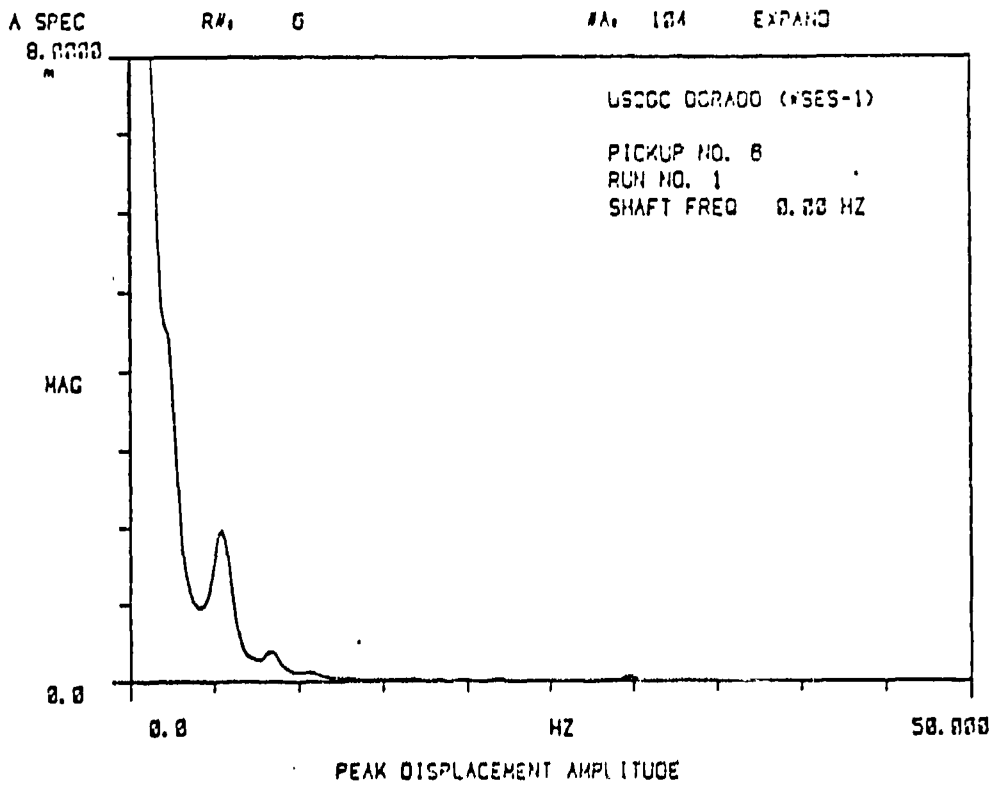

A SPEC
R#: 29
#A: 103
EXPAND
8.0000
m
USCGC DORADO (WSES-1)
PICKUP NO. 1
RUN NO. 11
SHAFT FREQ 12.95 HZ
MAG
0.0
0.0
HZ
100.00
PEAK DISPLACEMENT AMPLITUDE

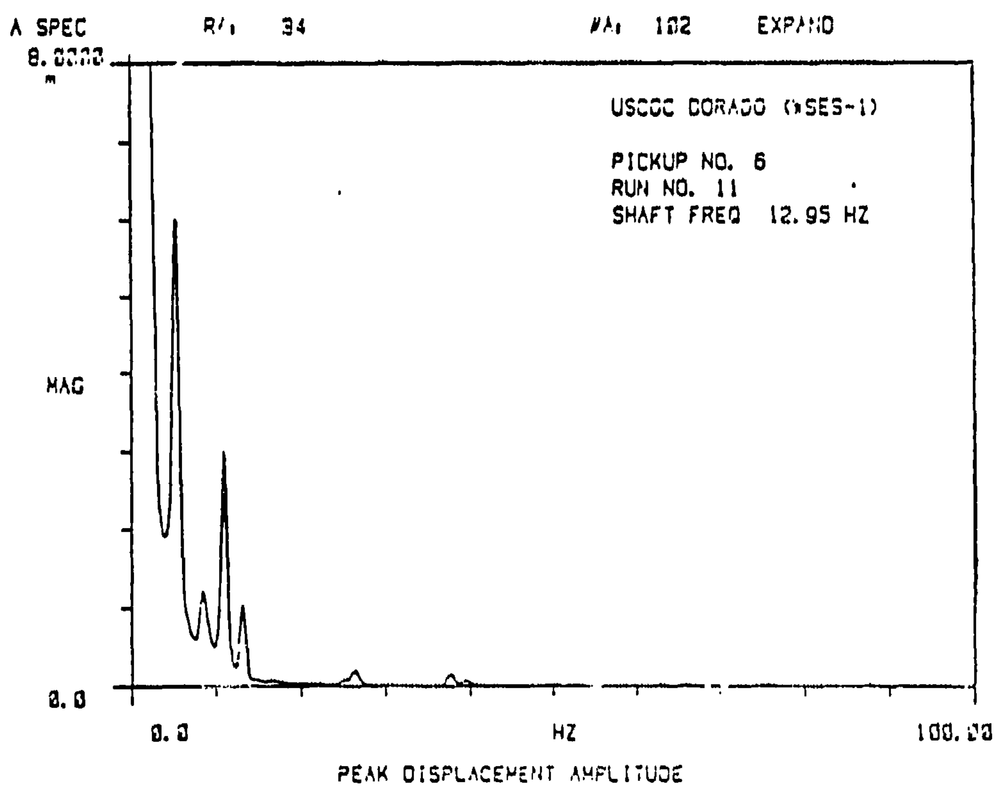

A SPEC
RW: 3
#A: 103
EXPAND
m
USCGC DORADO (WSES-1)
PICKUP NO. 3
RUN NO. 1
SHAFT FREQ 0.00 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE

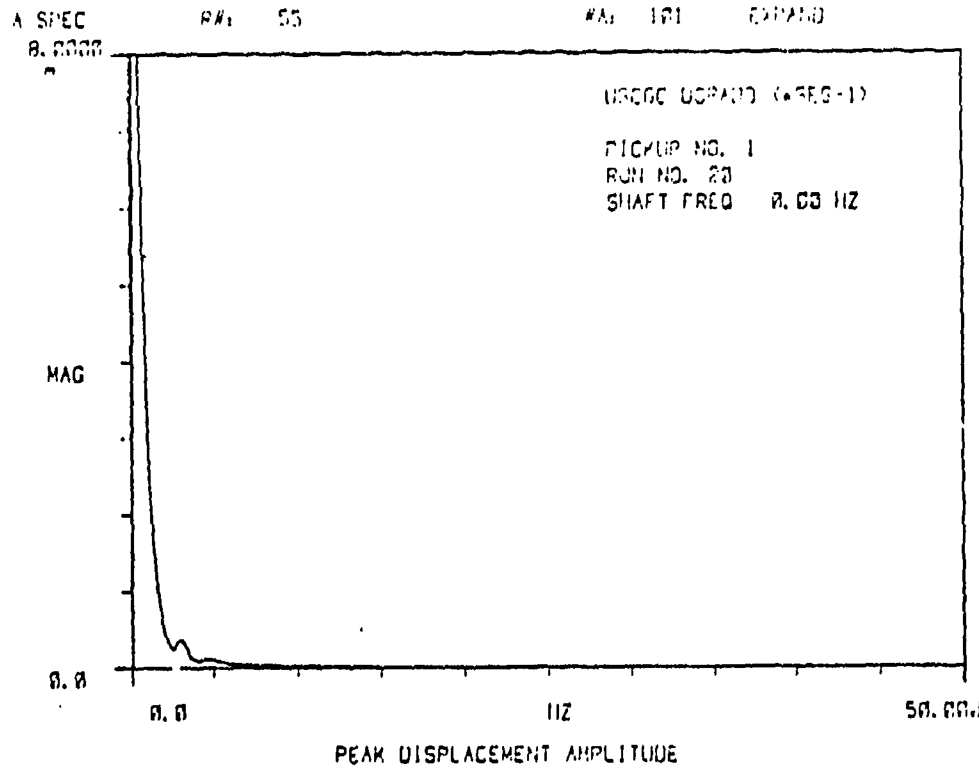

A SPEC
RW: 31
#A: 102
EXPAND
m
USCGC DORADO (WSES-1)
PICKUP NO. 3
RUN NO. 11
SHAFT FREQ 12.95 HZ
MAG
0.0
0.0
HZ
100.00
PEAK DISPLACEMENT AMPLITUDE


A SPEC
R#: 4
#A: 103
EXPAND
8.0000
m
USCGC DORADO (WSES-1)
PICKUP NO. 4
RUN NO. 1
SHAFT FREQ 0.00 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE

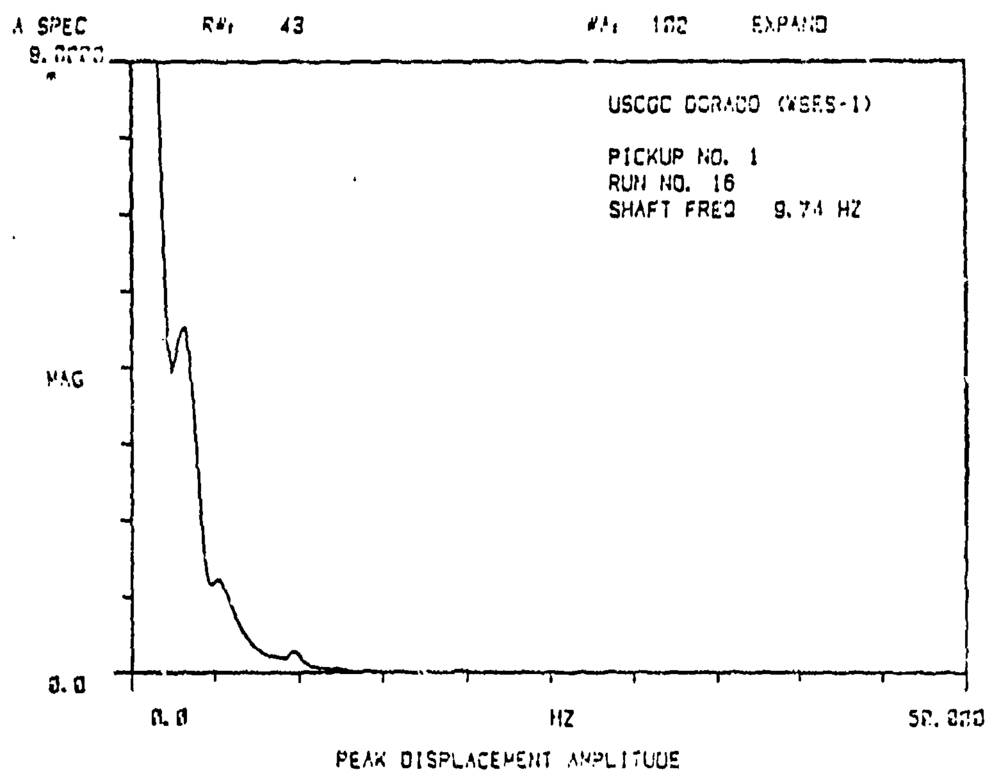

A SPEC
R#: 32
#A: 102
EXPAND
8.0000
m
USCGC DORADO (WSES-1)
PICKUP NO. 4
RUN NO. 11
SHAFT FREQ 12.95 HZ
MAG
0.0
0.0
HZ
100.00
PEAK DISPLACEMENT AMPLITUDE


A SPEC
R#: 6
#A: 104
EXPAND
8.0000
m
USCGC DORADO (*SES-1)
PICKUP NO. 6
RUN NO. 1
SHAFT FREQ 0.00 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE

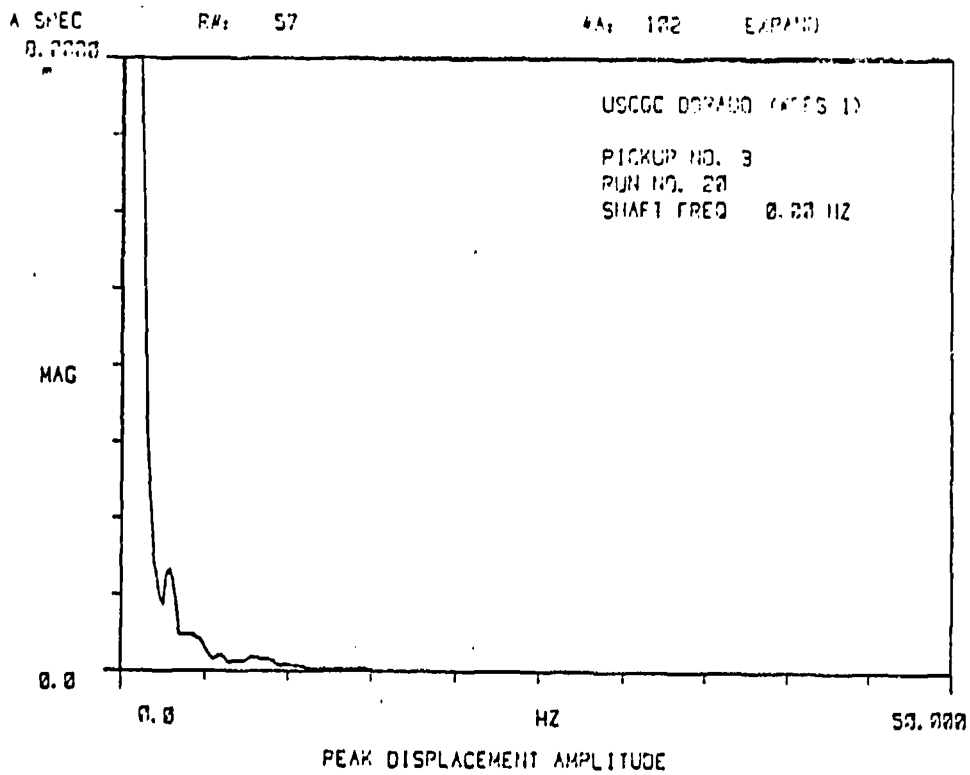

A SPEC
R#: 34
#A: 102
EXPAND
8.0000
m
USCGC DORADO (*SES-1)
PICKUP NO. 6
RUN NO. 11
SHAFT FREQ 12.95 HZ
MAG
0.0
0.0
HZ
100.00
PEAK DISPLACEMENT AMPLITUDE

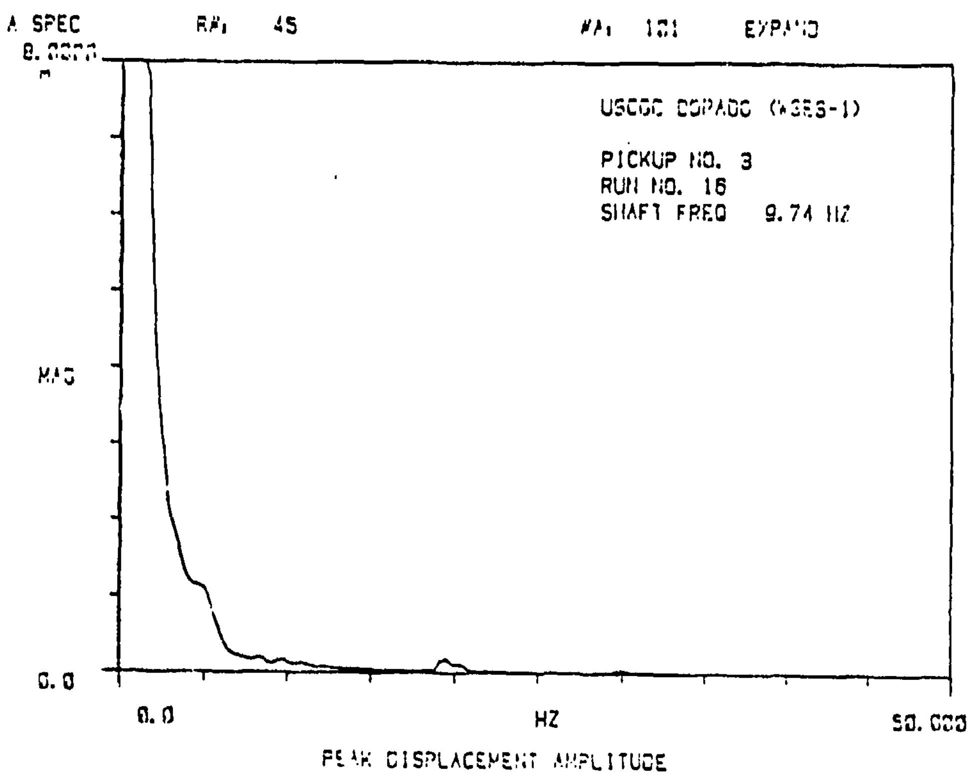


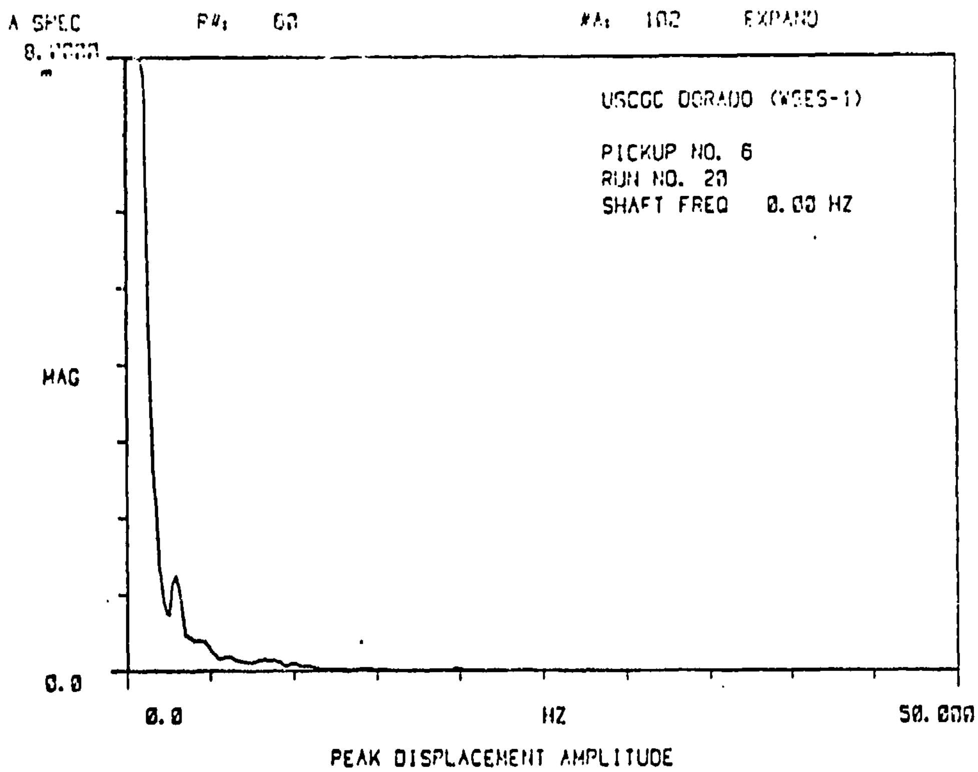
A SPEC
R#: 55
#A: 101
EXPAND
8.0000
USCGC DORADO (WSES-1)
PICKUP NO. 1
RUN NO. 20
SHAFT FREQ 0.00 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE

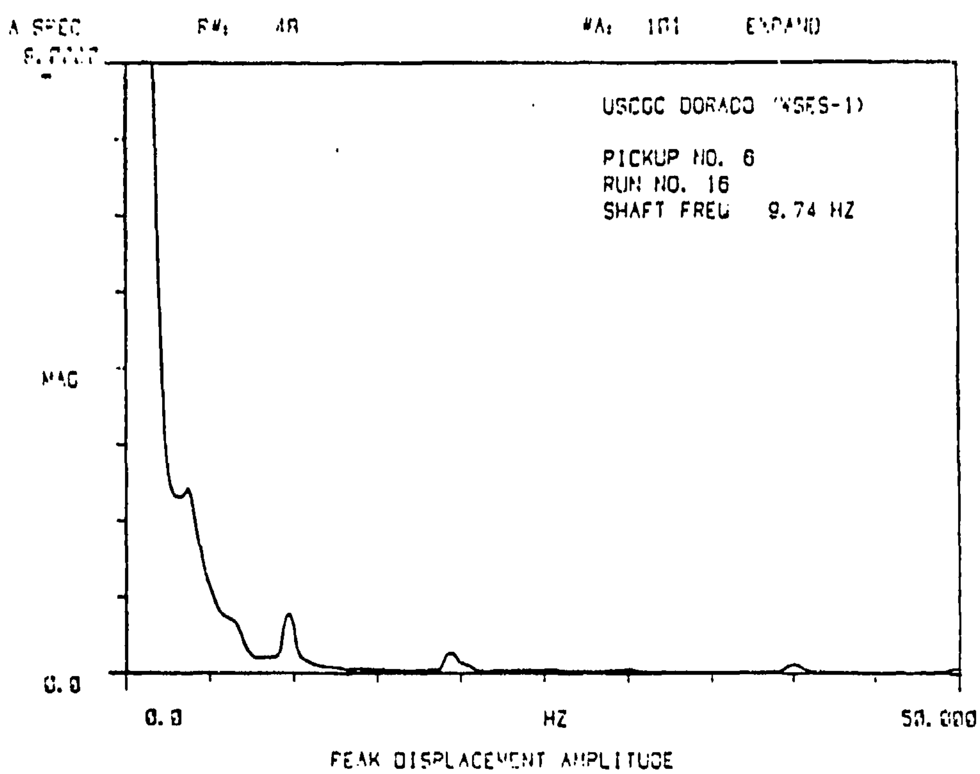


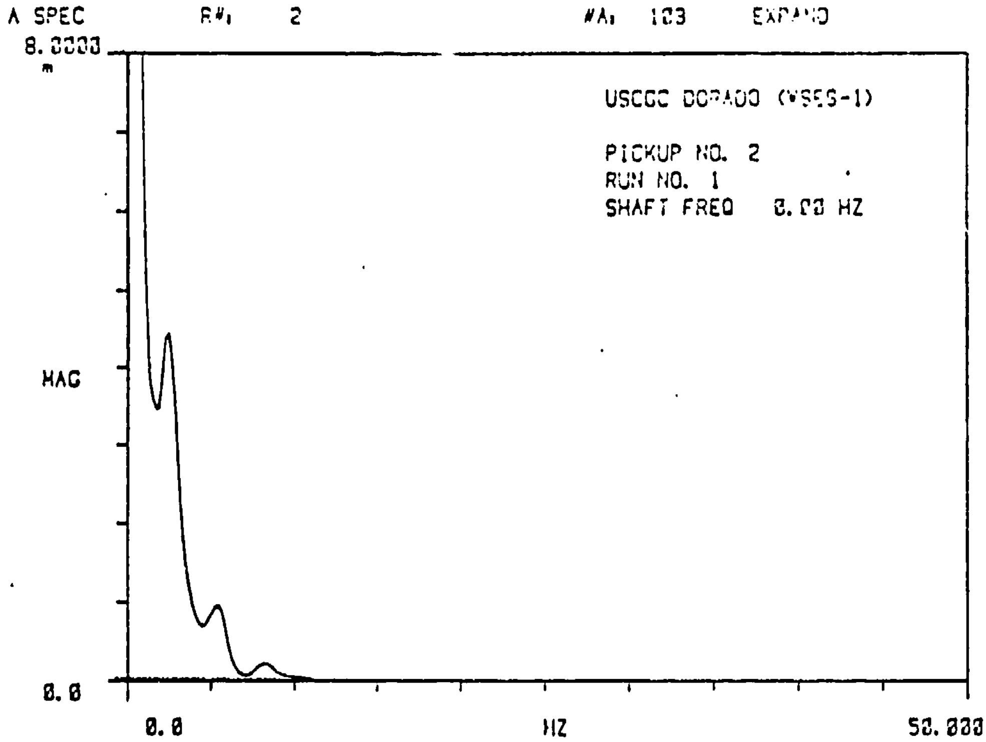
A SPEC
R#: 43
#A: 102
EXPAND
USCGC DORADO (WSES-1)
PICKUP NO. 1
RUN NO. 16
SHAFT FREQ 9.74 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE


A SPEC
RA: 57
#A: 182
EXPAND
0.0000
MAG
0.0
USCGC DORADO (WSES 1)
PICKUP NO. 3
RUN NO. 20
SHAFT FREQ 0.00 HZ
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE

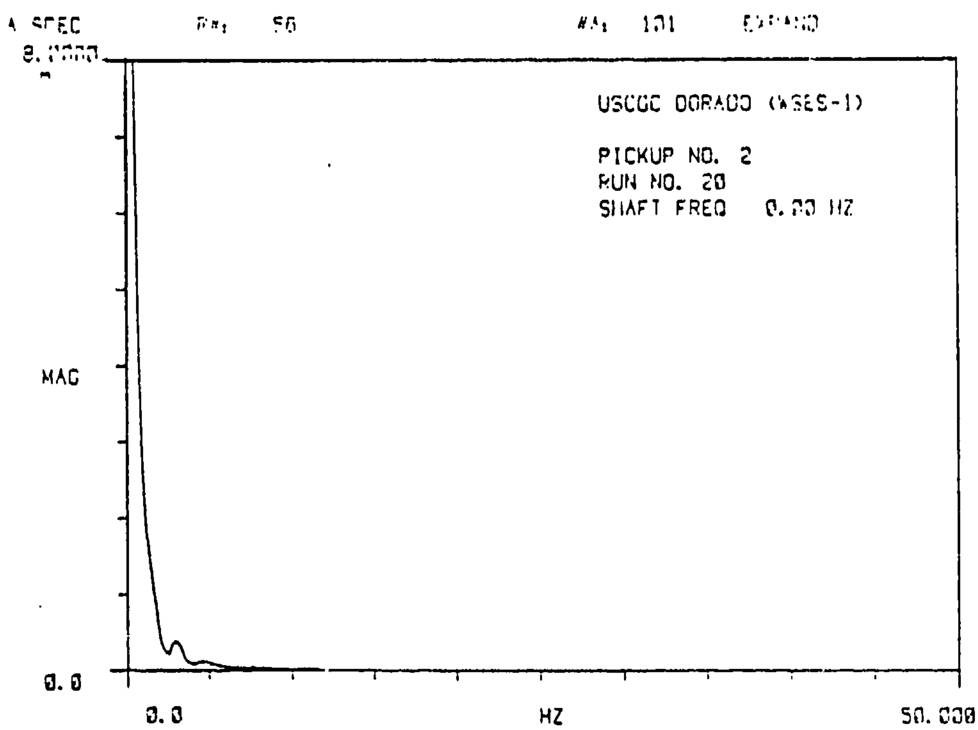

A SPEC
RA: 45
#A: 101
EXPAND
0.0000
MAG
0.0
USCGC DORADO (WSES-1)
PICKUP NO. 3
RUN NO. 16
SHAFT FREQ 9.74 HZ
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE


A SPEC
F#: 60
#A: 102
EXPAND
USCGC DORADO (WSES-1)
PICKUP NO. 6
RUN NO. 20
SHAFT FREQ 0.00 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE


A SPEC
F#: 48
#A: 101
EXPAND
USCGC DORADO (WSES-1)
PICKUP NO. 6
RUN NO. 16
SHAFT FREQ 9.74 HZ
MAG
0.0
0.0
HZ
50.000
PEAK DISPLACEMENT AMPLITUDE



PEAK DISPLACEMENT AMPLITUDE



PEAK DISPLACEMENT AMPLITUDE

APPENDIX B
COMPUTER PROGRAMS

COMMENTS ON PROGRAM "SES"

This is the master program used in the field to collect data for the DORADO tests. It can be used as a model for other ship tests as well. Much of what is included is of a general nature. Routines to initialize equipment and test to insure that equipment is running properly are included. The program stores up to ten minutes of data on floppy disks. The data is stored identically on two floppy disks with check read. This means that the data is read off the disks after being stored and compared to internal memory. This insures that what is on the disks is what was intended. Loran-C data can also be collected and continuously plotted if desired. The program contains provisions to read any of the data desired back from the disk after a run and print it out.

The main program runs self tests on instruments which have this capability. All instrumentation was on interface #8 except the floppy disk on interface #7 and the Loran-C on interface #11. After initializing equipment the main program transfers control to the data-collecting sub-program "Seststt".

Sub-program "Init" initializes the devices on the #8 bus and prints a list of the devices on the bus.

Sub-program "Seststt" is the main data collection routine. It allows for initial test setup and then waits for the test to start at line 2170. Pushing CONTINUE on the computer will start the test sequence. The test can be run for an integer number of minutes from 1 to 10. The loops from line 2230 to line 2680 comprise all the data collection statements. In the case of the SES tests, four data items were read each second (scanner channels 1-4). On alternate seconds, frequency and time delay were read from the two counters. Every four seconds a beep tone was generated to assist in recording data from the Loran-C. Every 15 seconds the time was checked and data printed. Provision was made to read digital data from the horsepower meter but this was not used.

Each minute seven additional channels were read (scanner channels 5-11). This process is repeated for the number of minutes specified. After all data is collected it is stored on disk in subroutine "Diskst". As previously stated, this routine stores duplicate copies of the data using check read. Whenever the amount of data changes, the number of records allocated for storage of this data must be adjusted in line 2960. This subroutine tries to be forgiving of recoverable errors and many of the statements are for this purpose.

After storing the data, the "Seststt" sub-program allows the operator to print some of the data. If this is desired then sub-program "Datanl" is called. This sub-program reads the stored data off the disks and offers a menu of data items to be printed. The operator selects one of these by number and the program decodes and scales the data type specified and then prints it. After printing the data the program loops back to the menu. This routine must agree with the data collected and is only correct for the SES test data. The calculations are straightforward and should be easily adjusted for different data.

Sub-program "Unpk56" is a Hewlett-Packard supplied routine for decoding packed data from the 3456A Digital Voltmeter. Data is stored on disk in this packed format.

Sub-program "Latlong" decodes the data string from the Loran-C and converts it into x-y coordinates for use on the plotter. If the data cannot be converted it is ignored.

```
10            ! *** MAIN PROGRAM "SES" ***
20            !
30            PRINTER IS 8,28
40            PRINT "************************************************************"
50            PRINT
60     !      PRINT "*   This program was designed for the test"
70     !      PRINT "*   of the Bell-Halter 110' SES."
80     !      PRINT "*   It uses the scanner, 3456 dvm, the disk drive,"
90     !      PRINT "*   and the printer.  The system voltmeter isn't used."
100    !      PRINT "*   Voltmeter complete should be connected to ext. inc."
110    !      PRINT "*"
120    !      PRINT "*   Loran C should be connected to RS-232 interface #11"
130    !      PRINT "*   Set Loran C mode 14 to 999999"
140    !      PRINT "*   Set mode 15 to month/day i.e. 0411 for APRIL 11"
150    !      PRINT "*   Set mode 12 to 1"
160    !      PRINT "*"
170           PRINT "*   Turn on the equipment and press CONTINUE when ready."
180           PRINT
190           PRINT "************************************************************"
200           PAUSE
210           OPTION BASE 1
220           COM Scn,Dvm,Svm,Ctr1,Ctr2,Plt,Prt,Xmin,Xmax,Ymin,Ymax,INTEGER Filcou
nt
230           COM Time$(1:10,0:4)[16],Secdat$(10)[960],Mindat$(10)[28]
240           COM Posdat$(0:50)[290],Digdat$(10,4)[12],Rpmdat$(10,60)[42]
250           INPUT "LOOK AT PREVIOUS DATA ONLY?",A$
260           IF A$[1,1]<>"Y" THEN Cont
270 File:     INPUT "WHICH FILE <SES01,SES20..>",File$
280           ON ERROR GOTO File
281           PRINT LIN(1),File$,LIN(1)
290           Filcount=VAL(File$[4;2])
300           OFF ERROR
310           Noloran=0
320           INPUT "WAS LORAN USED?",A$
330           IF A$[1,1]<>"Y" THEN Noloran=1
340           CALL Datanl(Noloran)
350           GOTO End
360 Cont:     Filcount=0
370           PRINT "Set Front/Back switch on 3456 DVM to Front"
380           BEEP
390           DISP "PUSH CONTINUE WHEN READY"
400           PAUSE
410           CALL Init
420           SET TIMEOUT 8;5000
430           ON INT #8,5 GOSUB Timout
440           RESET 8
450           OUTPUT Dvm;"TE1"
460           ENTER Dvm;A
470           IF A<>100 THEN Dvmerr
480           OUTPUT Dvm;"TE0"
490           PRINT "Voltmeter passed selftest"
500           OUTPUT Scn;"ST1"
510           ENTER Scn;A$
520           IF A$<>"SE8" THEN Scnerr
530           OUTPUT Scn;"ST0"
540           PRINT "Scanner passed selftest"
550           OUTPUT Ctr1;"IN"
560           OUTPUT Ctr2;"IN"
570           PRINT "Counters passed selftest"
```

```
580          INPUT "WILL LORAN BE USED?",A$
590          IF A$[1,1]<>"Y" THEN Noloran=1
600          IF Noloran THEN Skip
610          DISP "INITIALIZE PLOTTER"
620          PLOTTER IS 8,5,"9872A"
630          BEEP
640          OUTPUT Plt;"IN"
650          WAIT 2000
660          DISP "ENTER OPS CORNER POINTS OF PLOT"
670          LOCATE
680          WAIT 2000
690          INPUT "Lower left LONG <Deg,Min>",Deg1,Min1
700          INPUT "Lower left LAT <Deg,Min>",Deg2,Min2
710          INPUT "Upper right LONG <Deg,Min>",Deg3,Min3
720          INPUT "Upper right LAT <Deg,Min>",Deg4,Min4
730          Xmin=Deg1+Min1/60
740          Xmax=Deg3+Min3/60
750          Ymin=Deg2+Min2/60
760          Ymax=Deg4+Min4/60
770 Skip:    CALL Seststat(Noloran)
780 End:     PRINT "PROGRAM COMPLETED"
790          STOP
800 Dvmerr:  PRINT "Selftest error occurred on voltmeter."
810          PRINT "Make sure 3456 Dvm is on and nothing is"
820          PRINT "connected to its input terminals."
830          PRINT "Run this program again to recheck."
840          BEEP
850          STOP
860 Scnerr:  PRINT "Selftest error occurred on scanner."
870          Index=NUM(A$)
880          ON Index GOSUB Ermes1,Ermes2,Ermes3
890          PRINT "Check scanner and rerun program to recheck."
900          BEEP
910          STOP
920 Ermes1:  PRINT "Cross guard failure"
930          RETURN
940 Ermes2:  PRINT "A/D failure"
950          RETURN
960 Ermes3:  PRINT "Timer failure"
970          RETURN
980 Timout:  IF NOT TIME OUT(8) THEN RETURN
990          PRINT "A timeout occurred during an output or enter operation"
1000         BEEP
1010         RETURN
1020         END
1030         ! **********************************
1040         !
1050         !
1060         !
1070 SUB Init
1080 !
1090 COM Scn,Dvm,Svm,Ctr1,Ctr2,Plt,Prt
1100 DIM Message$[24]
1110 INTEGER Address
1120 ! INITIALIZE  DEVICE ADDRESSES
1130 Computer=821              !   SYSTEM COMPUTER
1140 Scn=809                   !   3497A SCANNER ADDRESS
1150 Dvm=822                   !   3456A DIGITAL VOLTMETER ADDRESS
1160 Svm=825                   !   3437A SYSTEM VOLTMETER ADDRESS
```

```
1170 Prt=828                        !  9876A PRINTER ADDRESS
1180 Ctr1=823                       !  5316A COUNTER No. 1 ADDRESS
1190 Ctr2=824                       !  5316A COUNTER No. 2 ADDRESS
1200 Plt=805                        !  9872B PLOTTER ADDRESS
1210 Bus=Scn DIV 100
1220 ! VERIFY THAT INTERFACE IS HP-IB
1230 READ IO Bus,5;Signature     !  SIGNATURE OF 98034A HP-IB INTERFACE
1240 IF BIT(Signature,"XX00XXXX") THEN Message$="PRESENT"
1250 IF NOT BIT(Signature,"XX00XXXX") THEN Message$="HP-IB"
1260 IF BIT(Signature,"XX11XXXX") THEN Hpib
1270 OUTPUT 8,28 USING "/,10X,K,K,K,2/,21X,K";"CAUTION:   INTERFACE  #";Bus;"  I
S   NOT   "&Message$;"ABNORMAL TERMINATION OF PROGRAM."
1280 BEEP
1290 STOP
1300 Hpib:ABORTIO Bus                      !  INITIALIZES INTERFACE AND BUS
1310 RESET Bus                       !  SENDS DEVICE CLEAR (DCL)
1320 ! CHECK FOR EQUIPMENT ON BUS AT ALL ADDRESSES AND PRINT DEVICE NAMES
1330 OUTPUT 8,28 USING "/,25X,K,DD,K,/";" EQUIPMENT PRESENT ON BUS #"&CHR$(132);
Bus;CHR$(128)
1340    FOR Address=0 TO 30
1350         OUTPUT Bus,Address USING "#"    ! ADDRESS DEVICE TO LISTEN
1360         STATUS Bus;A,A,A,Onbus           ! SEE IF IT LISTENED
1370         IF NOT BIT(Onbus,2) THEN Nxt    ! BIT 2 TRUE IF DEVICE PRESENT
1380         Message$="        Device Unknown"
1390         IF Address=Computer MOD 100 THEN Message$="9835B  System Computer"
1400         IF Address=Scn MOD 100 THEN Message$="3497A  Mainframe"
1410         IF Address=Dvm MOD 100 THEN Message$="3456A  Digital Voltmeter"
1420         IF Address=Svm MOD 100 THEN Message$="3437A  System Voltmeter"
1430         IF Address=Prt MOD 100 THEN Message$="9876A  Printer"
1440         IF Address=Ctr1 MOD 100 THEN Message$="5316A  Counter No. 1"
1450         IF Address=Ctr2 MOD 100 THEN Message$="5316A  Counter No. 2"
1460         IF Address=Plt MOD 100 THEN Message$="9872B  Plotter"
1470         OUTPUT 8,28 USING Fmt;Message$;Address
1480 Nxt:NEXT Address
1490 Fmt: IMAGE 20X,24A," at address ",2Z
1500 SUBEND
1510 !
1520 !
1530 !
1540           SUB Sestst(Noloran)
1550 ! *****************************************************************
1560 ! THIS IS SUBPROGRAM "Sestst" WHICH COLLECTS DATA FOR THE SES TESTS
1570 ! *****************************************************************
1580 !
1590           OPTION BASE 1
1600           INTEGER Posind,Runtime,Min,Sec
1610           COM Scn,Dvm,Svm,Ctr1,Ctr2,Plt,Prt,Xmin,Xmax,Ymin,Ymax,INTEGER Filcou
nt
1620           COM Time$(*),Secdat$(*),Mindat$(*)
1630           COM Posdat$(*),Digdat$(*),Rpmdat$(*)
1640           ! ********************************
1650 Init:     OVERLAP
1660           ABORTIO 8
1670           RESET 8
1680           IF Noloran THEN Skip
1690           SCALE Xmin,Xmax,Ymin,Ymax
1700           RESET 11
1710 Skip:     REMOTE 8
1720           OUTPUT Scn;"SISE0SD1TI0"
```

```
1730          INPUT "Do you want to change time",A$
1740          IF A$[1,1]<>"Y" THEN Keeptime
1750          A$=""
1760          PRINT "Enter time of day into scanner manually"
1770          BEEP
1780          PRINT "Code is: Shift,T,D,MMDDHHMMSS,Exec"
1790          LOCAL 8
1800          DISP "PUSH CONTINUE WHEN READY"
1810          PAUSE
1820          REMOTE 8
1830 Keeptime:OUTPUT Dvm;"HT4Z01STN1STI.05STDM0D1P101SM000S01"
1840          WAIT 1000
1850          LOCAL LOCKOUT 8
1860 Frntswt:OUTPUT Dvm;"SW1"
1870          ENTER Dvm;A$
1880          IF A$="0" THEN Rearswt
1890          BEEP
1900          PRINT "Front/Rear switch set to front"
1910          PRINT "Program waiting for you to change it."
1920          DISP "PUSH CONTINUE WHEN READY"
1930          PAUSE
1940          GOTO Frntswt
1950 Rearswt:INPUT "How long is test (1-10 mins)",Runtime
1960          IF (Runtime>10) OR (Runtime<1) THEN Rearswt
1970          REDIM Time$(1:Runtime,0:4),Secdat$(Runtime),Mindat$(Runtime)
1980          REDIM Digdat$(Runtime,4),Rpmdat$(Runtime,60)
1990          IF Noloran THEN Ready
2000          REDIM Posdat$(0:50)
2010 Retry:   Posind=0
2020          ON INT #11 GOTO Loranok
2030          DISP "WAITING ON LORAN-C"
2040          ENTER 11 BINT NOFORMAT;Posdat$(0)
2050          CARD ENABLE 11
2060          ENABLE
2070 Wait1:   GOTO Wait1
2080 Loranok:OFF INT #11
2090          PRINT Posdat$(0)
2100          CALL Latlong(Posind,Posdat$(*),Goodata,Xxx,Yyy)
2110          IF Goodata THEN MOVE Xxx,Yyy
2120          IF NOT Goodata THEN Retry
2130 Ready:   PRINT LIN(2),"Program standing by for test"
2140          PRINT "PRESS CONTINUE TO START TEST",LIN(2)
2150          BEEP
2160          DISP "STANDING BY FOR TEST"
2170          PAUSE
2180          ENABLE
2190          IF NOT Noloran THEN GOSUB Loranc
2200          ON INT #8 GOTO Scnint
2210          CONTROL MASK 8;128
2220          ! ********************************
2230 FOR Min=1 TO Runtime
2240          Mindat$(Min)=""
2250          SET TIMEOUT 8;1000
2260          OUTPUT Scn;"TD"
2270          ENTER Scn;Time$(Min,0)
2280          PRINT "START OF TEST MINUTE ";Min;" AT ";Time$(Min,0)
2290          OUTPUT Scn;"ARAF1AL4AC1AE1TI1SE010"
2300          Secdat$(Min)=""
2310 FOR Sec=1 TO 60
```

```
2320          CARD ENABLE 8
2330 Wait:    GOTO Wait
2340          ! ********************************
2350 Scnint:STATUS Scn;S
2360          IF S=72 THEN Cont1
2370          GOSUB Timout
2380          GOTO Cont3
2390 Cont1:  FOR K=1 TO 4
2400              OUTPUT Dvm;"T3"
2410              ENTER Dvm NOFORMAT;Sdat$
2420              Secdat$(Min)=Secdat$(Min)&Sdat$
2430          NEXT K
2460          IF Sec MOD 2=0 THEN
2461          OUTPUT Ctr1;"IN"
2462          OUTPUT Ctr2;"IN"
2465          ELSE
2466          OUTPUT Ctr1;"FN2"
2467          OUTPUT Ctr2;"FN2"
2468          END IF
2469          ENTER Ctr1;Rpmdat$(Min,Sec)[1;21]
2470          ENTER Ctr2;Rpmdat$(Min,Sec)[22,42]
2480          IF Sec MOD 4=0 THEN BEEP
2490          IF Sec MOD 15=0 THEN Gettime
2500          GOTO Cont3
2510          !
2520 Gettime:OUTPUT Scn;"TD"
2530          ENTER Scn;Time$(Min,Sec/15)
2540          PRINT Time$(Min,Sec/15),"  STATUS OK"
2550 !        OUTPUT Scn;"DL1"
2560 !        ENTER Scn;Digdat$(Min,Sec/15)
2570 !        OUTPUT Scn;"DL2"
2580 !        ENTER Scn;Ddata$
2590 !        Digdat$(Min,Sec/15)=Digdat$(Min,Sec/15)&Ddata$
2591          Digdat$(Min,Sec/15)="000000000000"
2600          IF Sec<60 THEN Cont3
2610          OUTPUT Scn;"TI0ARAF5AL11AC5AE1"
2620          FOR K=1 TO 7
2630          OUTPUT Dvm;"T3"
2640              ENTER Dvm NOFORMAT;Mdat$
2650              Mindat$(Min)=Mindat$(Min)&Mdat$
2660          NEXT K
2670 Cont3:  NEXT Sec
2680 NEXT Min
2690          OFF INT #11
2700          OFF INT #8
2710          DISABLE
2720          OUTPUT Scn;"TD"
2730          ENTER Scn;Td$
2740          PRINT "END OF TEST AT ",Td$,LIN(1)
2750          IF NOT Noloran THEN PEN 0
2760          ! ********************************
2770          GOSUB Diskst
2780          BEEP
2790          INPUT "Do you want to PRINT data?",A$
2800          IF A$[1,1]="Y" THEN CALL Datanl(Noloran)
2810          INPUT "Do you wish to take more data",A$
2820          IF A$[1,1]="Y" THEN Init
2830          SUBEXIT
2840          ! ********************************
```

```
2850 Diskst:! SUBROUTINE WHICH STORES DATA ON 9895 DISKS
2860         ! TWO COPIES OF THE DATA ARE RECORDED
2870         ! EACH WITH CHECK READ ENABLED
2880         SERIAL
2890         Filcount=Filcount+1
2900 Incnt:  !
2910         File1$="SES"&VAL$(Filcount)&":H7,0,0"
2920         File2$="SES"&VAL$(Filcount)&":H7,0,1"
2930         Posind=Posind-1
2940         IF Noloran THEN Posind=0
2950         ON ERROR GOTO Errf
2960         Norcrd=INT((Runtime*3916+Posind*295)/256+5)
2970 Tryagn:CREATE File1$,Norcrd
2980         CREATE File2$,Norcrd
2990         PRINT "FILENAME IS 'SES";Filcount;"'"
3000         ASSIGN #1 TO File1$,Ret0
3010         ASSIGN #2 TO File2$,Ret1
3020         IF Ret0 OR Ret1 THEN Filerr
3030         CHECK READ #1
3040         CHECK READ #2
3050         REDIM Posdat$(0:Posind)
3060         PRINT #1;Runtime,Time$(*)
3070         PRINT #1;Secdat$(*)
3080         PRINT #1;Mindat$(*)
3090         IF NOT Noloran THEN PRINT #1;Posind,Posdat$(*)
3100         PRINT #1;Digdat$(*)
3110         PRINT #1;Rpmdat$(*),END
3120         PRINT #1;END
3130         PRINT #2;Runtime,Time$(*)
3140         PRINT #2;Secdat$(*)
3150         PRINT #2;Mindat$(*)
3160         IF NOT Noloran THEN PRINT #2;Posind,Posdat$(*)
3170         PRINT #2;Digdat$(*)
3180         PRINT #2;Rpmdat$(*)
3190         PRINT #2;END
3200         PROTECT File1$,"SES"
3210         PROTECT File2$,"SES"
3220         ASSIGN #1 TO *
3230         ASSIGN #2 TO *
3240         OFF ERROR
3250         RETURN
3260 Errf:   IF (ERRN=80) OR (ERRN=83) OR (ERRN=85) OR (ERRN=89) OR (ERRN=64) OR
(ERRN=54) THEN Cont5
3270         DISP ERRM$
3280         WAIT 5000
3290         PRINT "ERROR MAY BE RECOVERABLE"
3300         BEEP
3310         INPUT "DO YOU WANT TO CONTINUE (Y/N)",A$
3320         IF A$[1,1]="Y" THEN Redo
3330         PRINT "DATA FROM THIS RUN LOST"
3340         RETURN
3350 Cont5:  IF ERRN<>80 THEN Cont6
3360         PRINT "Door open, check and push continue"
3370         BEEP
3380         PAUSE
3390         GOTO Repeat
3400 Cont6:  IF ERRN<>83 THEN Cont7
3410         PRINT "Media write protected, correct and push continue"
3420         BEEP
3430         PAUSE
```

```
3440          GOTO Repeat
3450 Cont7: IF ERRN<>85 THEN Cont8
3460          PRINT "Not initialized, insert initialized disk and push continue"
3470          BEEP
3480          PAUSE
3490          GOTO Repeat
3500 Cont8: IF ERRN<>89 THEN Cont9
3510          PRINT "Check read error, try a new disk, push continue when ready"
3520          BEEP
3530          PAUSE
3540          GOTO Repeat
3550 Cont9: IF ERRN<>64 THEN Cont10
3560          PRINT "Out of room on disk"
3570          PRINT "Insert a new pair of disks and push continue"
3580          BEEP
3590          PAUSE
3600 Cont10:Filcount=Filcount+1
3610          Posind=Posind+1
3620          GOTO Incnt
3630 Repeat:IF ERRL=2860 THEN 2970
3640          IF ERRL=2870 THEN 2980
3650          IF ERRL>=3010 THEN 3130
3660          IF ERRL>=2950 THEN 3060
3670 Redo:   !
3680          PURGE File1$
3690          PURGE File2$
3700          GOTO Tryagn
3710 Filerr:IF Ret1 THEN Retrn1
3720          ON Ret0 GOTO Err1,Er
3730 Retrn1:ON Ret1 GOTO Err1,Err2
3740 Err1:   PRINT "File could not be found on disk"
3750 Err2:   GOTO Redo
3760 Timout:IF NOT TIME OUT(8) THEN RETURN
3770          PRINT "A timeout occurred during an output or enter operation"
3780          PRINT "THIS WILL RESULT IN LOSS OF SOME DATA"
3790          BEEP
3800          RETURN
3810 Loranc: CALL Latlong(Posind,Posdat$(*),Goodata,Xxx,Yyy)
3820          IF Goodata THEN DRAW Xxx,Yyy
3830          Posind=Posind+1
3840          ON INT #11,7 GOSUB Loranc
3850          ENTER 11 BINT NOFORMAT;Posdat$(Posind)
3860          CARD ENABLE 11
3870          RETURN
3880          SUBEND
3890          !
3900          !
3910          !
3920   SUB Datanl(Noloran)
3930          ! ********************************
3940          ! THIS IS SUBPROGRAM "Datanl" WHICH CONVERTS
3950          ! AND PRINTS DATA FOR SES TESTS
3960          ! THIS PROGRAM IS A CONTINUATION OF "Seatst" AND
3970          ! RETURNS TO THAT PROGRAM WHEN THROUGH
3980          ! ********************************
3990          !
4000          OPTION BASE 1
4010          INTEGER Posind,Runtime,Time
4020          COM Scn,Dum,Sum,Ctr1,Ctr2,Plt,Pnt,Xmin,Xmax,Ymin,Ymax,INTEGER Filcou
```

```
nt
4030          COM Time$(*),Secdat$(*),Mindat$(*)
4040          COM Posdat$(*),Digdat$(*),Rpmdat$(*)
4050          DIM Secdat(240),Mindat(7)
4060          ! *********************************
4070          File$="SES"&VAL$(Filcount)&":H7"
4080          ASSIGN #1 TO File$,Ret,"SES"
4090          IF Ret THEN Filerr
4100          IF TYP(1)<>5 THEN Err3
4110          READ #1;Runtime
4120          ON END #1 GOTO Err3
4130          MAT READ #1;Time$(1:Runtime,0:4)
4140          MAT READ #1;Secdat$(Runtime)
4150          MAT READ #1;Mindat$(Runtime)
4160          IF Noloran THEN Skip
4170          IF TYP(1)<>5 THEN Err3
4180 Ind:     READ #1;Posind
4190          MAT READ #1;Posdat$(0:Posind)
4200 Skip:    MAT READ #1;Digdat$(Runtime,4)
4210          MAT READ #1;Rpmdat$(Runtime,60)
4220          OFF END #1
4230          IF TYP(1)<>3 THEN Err3
4240 Menu:    PRINT LIN(1),"What data do you want to look at?"
4250          PRINT "           Analog data taken each second = 1"
4260          PRINT "           Analog data taken each minute = 2"
4270          PRINT "           Position data                 = 3"
4280          PRINT "           Torque data each 15 seconds   = 4"
4290          PRINT "           RPM data taken each second    = 5"
4300          PRINT "           None, return to main program  = 6",LIN(1)
4310          INPUT "ENTER NUMBER OF YOUR CHOICE",Code
4320          PRINT Code;"ENTERED",LIN(1)
4330          ON ERROR GOTO Menu
4340          ON Code GOTO Sec,Min,Pos,Tor,Rpm,Exit
4350          OFF ERROR
4360 Sec:     ! Second data conversion
4370 Over:    INPUT "ENTER MINUTE YOU WANT DATA FOR",Time
4380          IF (Time>Runtime) OR (Time<=0) THEN Over
4390          PRINT "Minute";Time
4400          PRINT "DATA FROM ";Time$(Time,0);" TO ";Time$(Time,4)
4410          CALL Unpk56(Secdat$(Time),Secdat(*))
4420          PRINT LIN(2),"ANALOG DATA TAKEN EACH SECOND",LIN(1)
4430          PRINT "YAW ANGLE              YAW RATE                 RUDDER ANGLE      TOW
LINE FORCE"
4440          PRINT " degrees               degrees/sec              degrees
pounds",LIN(1)
4450          DEG
4460          FOR I=0 TO 59
4470          Aa=-4.237*Secdat(4*I+3)+19.499
4480          Rangle=2*ACS(SQR((19+Aa/2)*(19-Aa/2)/336))-54.75
4490          PRINT Secdat(4*I+1)*35-.46435,Secdat(4*I+2)*24-2.514583,Rangle,Secda
t(4*I+4)
4500          NEXT I
4510          GOTO Menu
4520 Min:     ! Minute data conversion
4530 Over1:   INPUT "ENTER MINUTE YOU WANT DATA FOR",Time
4540          IF (Time>Runtime) OR (Time<=0) THEN Over1
4550          PRINT "Minute";Time
4560          PRINT "DATA FOR ";Time$(Time,4)
4570          CALL Unpk56(Mindat$(Time),Mindat(*))
```

```
4580        PRINT LIN(2),"ANALOG DATA TAKEN EACH MINUTE",LIN(1)
4590        PRINT "Cushion pressure fwd = ";Mindat(1)*2.5;" psid"
4600        PRINT "Cushion pressure aft = ";Mindat(2)*2.5;" psid"
4610        PRINT "Fwd seal pressure    = ";Mindat(3)*2.5;" psid"
4620        PRINT "Aft seal pressure    = ";Mindat(4)*2.5;" psid"
4630        PRINT "Wind direction       = ";Mindat(5)*100;" Degrees relative"
4640        PRINT "Wind speed           = ";Mindat(6)*20;" MPH"
4650        PRINT "Pitch angle          = ";Mindat(7)*9;" Degrees"
4660        GOTO Menu
4670 Pos:   ! Position data
4680        IF Noloran THEN Posind=0
4690        PRINT "A total of ";Posind;" position data points were taken",LIN(1)
4700 Points:INPUT "FIRST AND LAST POINT OF DATA",First,Last
4710        IF (First>Last) OR (Last>Posind) OR (First<0) THEN Points
4720        FOR I=First TO Last
4730        PRINT LIN(1),"Position point no.";I,LIN(1)
4740        PRINT Posdat$(I)
4750        NEXT I
4760        GOTO Menu
4770 Tor:   ! Digital data conversion
4780 Over2: INPUT "ENTER MINUTE YOU WANT DATA FOR",Time
4790        IF (Time>Runtime) OR (Time<=0) THEN Over2
4800        PRINT "Minute";Time
4810        PRINT "DATA FROM ";Time$(Time,1);" TO ";Time$(Time,4)
4820        PRINT LIN(2),"TORQUE DATA TAKEN EVERY 15 SECONDS",LIN(1)
4830        PRINT " STBD TORQUE          PORT TORQUE",LIN(1)
4840        FOR I=1 TO 4
4850        PRINT TAB(5),Digdat$(Time,I)[1;6],TAB(25),Digdat$(Time,I)[7;6]
4860        NEXT I
4870        GOTO Menu
4880 Rpm:   ! Rpm data conversion
4890 Over3: INPUT "ENTER MINUTE YOU WANT DATA FOR",Time
4900        IF (Time>Runtime) OR (Time<=0) THEN Over3
4910        PRINT "DATA FROM ";Time$(Time,0);" TO ";Time$(Time,4)
4920        PRINT LIN(2),"RPM DATA TAKEN EACH SECOND",LIN(1)
4930        PRINT "SHAFT 1 RPM";TAB(21);" DELAY";TAB(40);"SHAFT 2 RPM";TAB(61);"
 DELAY",LIN(2)
4931        Avgdelay1=Avgdelay2=0
4940        FOR I=1 TO 60
4941              ENTER Rpmdat$(Time,I) USING "#,F";Rpm1,Rpm2
4960              IF Rpmdat$(Time,I)[1,1]="F" THEN
4961                    PRINT Rpm1*60;TAB(40);Rpm2*60
4962               ELSE
4963                    PRINT TAB(20);Rpm1;TAB(60);Rpm2
4964                    Avgdelay1=Avgdelay1+Rpm1/30
4965                    Avgdelay2=Avgdelay2+Rpm2/30
4970               END IF
5000        NEXT I
5001        PRINT LIN(2),"Avg delay";TAB(20);Avgdelay1;TAB(60);Avgdelay2
5010        GOTO Menu
5020 Err3:  DISP "Incorrect data type found"
5030        WAIT 3000
5040        SUBEXIT
5050 Filerr:ON Ret GOTO Err1,Err2
5060 Err1:  PRINT "File could not be found on disk"
5070 Err2:  PRINT "RETURN VARIABLE = ";Ret
5080 Exit:  SUBEND
5090 !
5100 !
5110 !
```

```
5120  SUB Unpk56(In$,Out(*))                                  !  9835/45  REV. A  6/23/80
5130  !
5140  INTEGER N,J,I,B1,B2,B3,B4
5150  N=LEN(In$)
5160  J=0                                                                  ! DO THE UNPACK
5170  FOR I=1 TO N STEP 4
5180  J=J+1
5190  B1=NUM(In$[I])
5200  B2=NUM(In$[I+1])
5210  B3=NUM(In$[I+2])
5220  B4=NUM(In$[I+3])
5230  Out(J)=.1*BIT(B1,0)+.01*SHIFT(B2,4)+.001*BINAND(B2,15)+.0001*SHIFT(B3,4)+.
00001*BINAND(B3,15)+.000001*SHIFT(B4,4)+.0000001*BINAND(B4,15)
5240  Out(J)=Out(J)*(1-2*BIT(B1,1))*10^((1-2*BIT(B1,7))*SHIFT(BINAND(B1,124),2))
5250  NEXT I
5260          SUBEND
5270          !
5280          !
5290          !
5300 SUB Latlong(INTEGER Posind,Posdat$(*),REAL Goodata,X,Y)
5310          ! ***************************
5320          ! THIS IS SUBPROGRAM "Latlong" WHICH
5330          ! CONVERTS DATA FROM THE LORAN-C TO NUMBERS WHICH
5340          ! CAN BE PLOTTED.
5350          ! THIS PROGRAM IS CALLED BY SUBPROGRAM "Seatst"
5360          ! AND RETURNS TO THAT PROGRAM WHEN DONE.
5370          ! **********************
5380          !
5390          J=0
5400 Goodata=1
5410          FOR I=50 TO 282
5420          IF Posdat$(Posind)[I;8]="POSITION" THEN J=I+8
5430          IF J<>0 THEN Cont
5440          NEXT I
5450          Goodata=0
5460          SUBEXIT
5470 Cont:    J1=0
5480          FOR I=0 TO 20
5490          IF (Posdat$(Posind)[J+I;1]>="0") AND (Posdat$(Posind)[J+I;1]<="9") T
HEN J1=I+J
5500          IF J1<>0 THEN Cont1
5510          NEXT I
5520          Goodata=0
5530          SUBEXIT
5540 Cont1:   K=J1
5550 GOSUB Checkval
5560          IF NOT Goodata THEN SUBEXIT
5570          Y=VAL(Posdat$(Posind)[K;2])+VAL(Posdat$(Posind)[K+3;5])/60
5580          J2=0
5590          FOR I=0 TO 20
5600          IF Posdat$(Posind)[J1+I;1]="N" THEN J2=I+J1
5610          IF J2<>0 THEN Cont2
5620          NEXT I
5630          Goodata=0
5640          SUBEXIT
5650 Cont2:   J3=0
5660          FOR I=0 TO 20
5670          IF (Posdat$(Posind)[J2+I;1]>="0") AND (Posdat$(Posind)[J2+I;1]<="9")
 THEN J3=I+J2
```

```
5680          IF J3<>0 THEN Cont3
5690          NEXT I
5700          Goodata=0
5710          SUBEXIT
5720 Cont3:   K=J3
5730          GOSUB Checkval
5740          IF NOT Goodata THEN SUBEXIT
5750          X=VAL(Posdat$(Posind)[K;2])+VAL(Posdat$(Posind)[K+3;5])/60
5760          SUBEXIT
5770 Checkval:Goodata=1
5780          ON ERROR GOTO Badata
5790          Dummy=VAL(Posdat$(Posind)[K;2])
5800          Dummy=VAL(Posdat$(Posind)[K+3;5])
5810          RETURN
5820 Badata:OFF ERROR
5830          Goodata=0
5840          IF ERRN<>32 THEN Error
5850          RETURN
5860 Error:   DISP "ERRM$"
5870          WAIT 4000
5880          RETURN
5890 SUBEND
```

COMMENTS ON PROGRAM "ZIGZAG"

This progrm was used to read yaw angle and rudder angle data from a floppy disk. It reads the data in the format used by the main test program SES to store it during the test.

The ZIGZAG program converts this data to the proper x,y coordinate form and stores three curves in file PLTDAT for use by the PLOTER program. These three curves in order are yaw angle vs. time, rudder angle vs. time, and displacement from base course vs. time. This latter curve is stored for only the first 120 seconds.

The program also calculates and prints the predicted latitude and longitude coordinates which result from moving in increments along the curve and calculating the next point based on speed and heading angle. Since the speed of the vessel changes in a turn, a factor, K_1 in line 920 is provided as a multiplier for ship speed. This factor can be used to adjust predicted latitude-longitude coordinates to agree with the actual values measured. This is necessary to generate an accurate displacement off the base course also.

The rudder angle calculation in lines 490-500 depends on the test configuration of the transducer. See Appendix E for a further discussion.

The program uses the first time (after 20 seconds) that the rudder angle exceeds 5 degrees as the execute time. Until this time the displacement off the base course is held at zero.

The yaw angle is averaged for an integral number of periods beginning with the first zero crossing after 60 seconds and running to the last full period prior to the end of the data.

The scale for displacement off the base course is expanded by 20 times. Therefore the plotted values can be displayed on the same scale as the yaw and rudder angle. For an angle scale running from -30 degrees to +30 degrees the displacement value scale should run from -1.5 to +1.5 ship lengths.

```
10          ! *** MAIN PROGRAM "ZIGZAG" ***
20          !
30       PRINTER IS 8,28
40       OPTION BASE 1
50       COM Prt,INTEGER Filcount
60       COM Time$(1:10,0:4)[16],Secdat$(10)[960]
70       Prt=828
80 File: INPUT "WHICH FILE (SES01,SES20..)",File$
90       ON ERROR GOTO File
100      Filcount=VAL(File$[4;2])
110      OFF ERROR
120      Noloran=1
130      CALL Datanl(Noloran)
140      END
150         ! ********************************
160         !
170         !
180         !
190      SUB Datanl(Noloran)
200         !
210           OPTION BASE 1
220           INTEGER Posind,Runtime,Time,Lat,Long,T1,T2,Nm
230           COM Prt,INTEGER Filcount
240           COM Time$(*),Secdat$(*)
250           DIM Secdat(240),Mindat(6)
260           DIM Sdat1(600),Sdat3(0:600)
270           DIM Sdat2(600),Sdat4(0:600)
280         ! ********************************
290           File$="SES"&VAL$(Filcount)&":H7"
300           ASSIGN #1 TO File$,Ret,"SES"
310           IF Ret THEN Filerr
320           N1=0
330           IF TYP(1)<>5 THEN Err3
340           READ #1;Runtime
350           INPUT "MINUTES OF DATA TO PLOT",Nm
360           IF Nm>Runtime THEN Nm=Runtime
370           IF Nm<=0 THEN STOP
380           Nopts=Nm*60
390         " ON END #1 GOTO Err3
400           MAT READ #1;Time$(1:Runtime,0:4)
410           MAT READ #1;Secdat$(Runtime)
420           DEG
430           FOR Min=1 TO Runtime-1
440                 CALL Unpk56(Secdat$(Min),Secdat(*))
450                 FOR Sec=0 TO 59
460                       I=(Min-1)*60+Sec+1
470                       Sdat1(I)=Secdat(4*Sec+1)*35
480                       IF (ABS(Sdat1(1))>90) AND (Sdat1(I)<0) THEN Sdat1(I)=360
+Sdat1(I)
490                       Aa=-6.791687*Secdat(4*Sec+3)+19.970
500                       Sdat2(I)=2*ACS(SQR((19.25+Aa/2)*(19.25-Aa/2)/340.31))-50
.643
510                 NEXT Sec
520           NEXT Min
530           PURGE "PLTDAT"
540           CREATE "PLTDAT",150
550           ASSIGN #2 TO "PLTDAT"
560           PRINT #2;Nopts
570           Avg=Sdat1(1)
```

```
580             FOR I=1 TO Nopts
590                  Sdat1(I)=Sdat1(I)-Avg
600             NEXT I
610             FOR I=60 TO Nopts
620                  IF SGN(Sdat1(I))<>SGN(Sdat1(I-1)) THEN
630                       T1=I
640                       GOTO Next
650                  END IF
660             NEXT I
670 Next:       J=0
680             FOR I=T1+1 TO Nopts
690                  IF SGN(Sdat1(I))<>SGN(Sdat1(I-1)) THEN J=J+1
700                  IF J MOD 2=0 THEN T2=I
710             NEXT I
720             Avg=0
730 Nxt:        FOR I=T1 TO T2
740                  Avg=Avg+Sdat1(I)
750             NEXT I
760             Avg=Avg/(T2-T1)
770             FOR I=1 TO Nopts
780                  Sdat1(I)=Sdat1(I)-Avg
790                  PRINT #2;I,Sdat1(I)
800             NEXT I
810             PRINT #2;Nopts
820             FOR I=1 TO Nopts
830                  PRINT #2;I,Sdat2(I)
840             NEXT I
850             N1=120
860             PRINT #2;N1
870             INPUT "Speed in Kts",Speed
880             Speed=Speed*1.689          ! FT/SEC
890             Sdat3(0)=Sdat4(0)=0
900             INPUT "SHIP LENGTH (Ft)",Length
910             Len=Length/20  ! Scale for Y/Loa 1/20 Scale for angles
920             K=1
930             Dispmax=0
940             Dispmin=0
950             I=1
960             REPEAT
970                  Sdat3(I)=0
980                  Sdat4(I)=Sdat4(I-1)+Speed*K
990                  IF I<=120 THEN PRINT #2;I,Sdat3(I)
1000                 I=I+1
1010            UNTIL (ABS(Sdat2(I))>5) AND (I>20)
1020            T0=I-1
1030            REPEAT
1040                 Sdat3(I)=Sdat3(I-1)+Speed*SIN(Sdat1(I))*K
1050                 Sdat4(I)=Sdat4(I-1)+Speed*COS(Sdat1(I))*K
1060                 IF Sdat3(I)>Dispmax THEN Dispmax=Sdat3(I)
1070                 IF Sdat3(I)<Dispmin THEN Dispmin=Sdat3(I)
1080                 IF I<=120 THEN PRINT #2;I,Sdat3(I)/Len
1090                 I=I+1
1100            UNTIL I>Nopts
1110            INPUT "Initial Lat-Long Deg-Min",Latd,Latm,Longd,Longm
1120            INPUT "Base Course Deg",Course
1130            Lat0=Latd+Latm/60
1140            Fact=COS(Lat0)
1150            PRINT PAGE,"Time                    Latitude            Longitude",LI
N(1)
```

```
1160            FOR I=1 TO Nopts
1170                 Beta=Course-ATN(Sdat3(I)/Sdat4(I))
1180                 L=Sdat4(I)/COS(Course-Beta)
1190                 Lat=(Latm+L*COS(Beta)/6078)*100
1200                 Long=(Longm-L*SIN(Beta)/(Fact*6078))*100
1210                 IF Lat>6000 THEN
1220                      Latd=Latd+Lat DIV 6000
1230                      Lat=Lat MOD 6000
1240                      Latm=Latm-60
1250                 END IF
1260                 IF Long>6000 THEN
1270                      Longd=Longd+Long DIV 6000
1280                      Long=Long MOD 6000
1290                      Longm=Longm-60
1300                 END IF
1310 Minus:          IF Lat<0 THEN
1320                      Latd=Latd-1
1330                      Lat=Lat+6000
1340                      Latm=Latm+60
1350                      GOTO Minus
1360                 END IF
1370 Minus1:         IF Long<0 THEN
1380                      Longd=Longd-1
1390                      Long=Long+6000
1400                      Longm=Longm+60
1410                      GOTO Minus1
1420                 END IF
1430                 Latm1=Lat/100
1440                 Longm1=Long/100
1450                 IF I MOD 4=0 THEN PRINT I,Latd;Latm1,Longd;Longm1
1460            NEXT I
1470            PRINT LIN(1),"Maximum Displacement =";Dispmax,"Minimum Displacemen
t =";Dispmin
1480            PRINT LIN(1),"EXECUTE TIME IS ";T0
1490            SUBEXIT
1500 Err3:      DISP "Incorrect data type found";
1510            WAIT 3000
1520            SUBEXIT
1530 Filerr:    ON Ret GOTO Err1,Err2
1540 Err1:      PRINT "File could not be found on disk"
1550 Err2:      PRINT "RETURN VARIABLE = ";Ret
1560 Exit:SUBEND
1570 !
1580 !
1590 !
1600      SUB Unpk56(In$,Out(*))                        !  9835/45  REV. A  6/23/80
1610  !
1620            INTEGER N,J,I,B1,B2,B3,B4
1630            N=LEN(In$)
1640            J=0                                                   ! DO THE UNPACK
1650            FOR I=1 TO N STEP 4
1660                 J=J+1
1670                 B1=NUM(In$[I])
1680                 B2=NUM(In$[I+1])
1690                 B3=NUM(In$[I+2])
1700                 B4=NUM(In$[I+3])
1710                 Out(J)=.1*BIT(B1,0)+.01*SHIFT(B2,4)+.001*BINAND(B2,15)+.0001*
SHIFT(B3,4)+.00001*BINAND(B3,15)+.000001*SHIFT(B4,4)+.0000001*BINAND(B4,15)
1720                 Out(J)=Out(J)*(1-2*BIT(B1,1))*10^((1-2*BIT(B1,7))*SHIFT(BINAN
```

```
D(B1,124),2))
1730          NEXT I
1740      SUBEND
```

COMMENTS ON PROGRAM "PLOTER"

This is a general purpose rectangular coordinate plotting routine developed by LCDR GOODWIN at the R&D Center. It can be used to plot data entered from the keyboard of the computer or from a stored data file, PLTDAT, stored as:

```
No. of Points

  x , y         One (x,y) pair must be
  x , y         included for each of the
  x , y         number of points specified
```

This file must be named "PLTDAT" and must be on mass storage unit :H7 which is a floppy disk.

The limits of the plotting area and other information are requested of the user as the program proceeds. An information block can be positioned in any of the four corners of the plot or be left out. Two lines of title are allowed. The vertical axis can be positioned on the right, in the middle, on the left or on both sides of the plot.

```
10    ! THIS IS PROGRAM "PLOTER", A GENERAL RECTANGULAR
20    ! COORDINATE PLOTTING ROUTINE FOR X AND Y VALUES.
30    ! UP TO 5 CURVES CAN BE PLOTTED ON ONE GRAPH.
40    !
50    !     *** MAIN PROGRAM ***
60    !
70        COM Xmin,Xmax,Ymin,Ymax,Xstepunit,Ystepunit,Xstep,Ystep,A$
80        DIM Lineid(5),Linesym$(5)[1]
90    !
          Plotter=805
          PLOTTER IS 8,5,"9872A"
120       DISP "Put paper on plotter, PUSH CONT"
130       PAUSE
140       LIMIT 0,279.5,0,216
150       LINE TYPE 4,4
160       FRAME! 8.5 X 11 CUT LINE
170       LINE TYPE 1
180       LIMIT 25,255,25,190! Sets plotting area limits
190       FRAME! Outline the plotting area
200       FRAME
210       LOCATE 22,117,12,85! Set scaling limits for plot
220       CLIP 21,118,11,86
230       CALL Axes
240       CALL Label_ticks
250       CALL Label_axes(A$)
260       CALL Title
270       CALL Info_block(Lineid(*),Numlines,Symbol$,Linesym$(*),Barcht)
271       CLIP 22,117,12,85
280 Repeat:INPUT "DATA FROM <FILE> OR <KEYBRD>",B$
290       IF (B$<>"FILE") AND (B$<>"KEYBRD") THEN Repeat
300       IF B$="FILE" THEN CALL Datafile(Lineid(*),Numlines,Symbol$,Linesym$(*))
310       IF B$="KEYBRD" THEN CALL Dataentry(Lineid(*),Numlines,Symbol$,Linesym$(
*),Barcht)
320       INPUT "Do you want to label plot?",B$
330       IF B$[1,1]="Y" THEN CALL Labels
340       PEN 0
350       OUTPUT Plotter;"IN"
360       END
370         !
380       SUB Axes
390         !
400           COM Xmin,Xmax,Ymin,Ymax,Xstepunit,Ystepunit,Xstep,Ystep,A$
410         !
420           A$="LEFT"
430           INPUT "DUAL VERT. AXES DESIRED?",B$
440           IF B$[1,1]<>"Y" THEN Rtaxis
450           A$="BOTH"
460           GOTO Newlimits
470 Rtaxis:   INPUT "RIGHT HAND AXES DESIRED",B$
480           IF B$[1,1]="Y" THEN A$="RIGHT"
490           IF A$="RIGHT" THEN Newlimits
500 Ctaxis:   INPUT "CENTER AXES DESIRED",B$
510           IF B$[1,1]="Y" THEN A$="CENTER"
520         !
530 Newlimits:INPUT "Min 'X' coordinate",Xmin
540           INPUT "Max 'X' coordinate",Xmax
550           INPUT "Min 'Y' coordinate",Ymin
560           INPUT "Max 'Y' coordinate",Ymax
570           CALL Check_limits(Error,Xmin,Xmax,Ymin,Ymax)
```

```
580            IF Error>0 THEN Newlimits
590  !
600            Lim=Xmin         ! This part of the program modifies
610            IF Lim=0 THEN Ylim ! the min and max limits of the
620            GOSUB Integer_val  ! axes for a neat plot
630            Xmin=Lim
640 Ylim:      Lim=Ymin
650            IF Lim=0 THEN Diff
660            GOSUB Integer_val
670            Ymin=Lim
680 Diff:      Lim=Xmax-Xmin
690            GOSUB Integer_val
700            X=Xmin+Lim
710            IF X>=Xmax THEN Correctx
720 Loopx:     X=X+I/10
730            IF X<Xmax THEN Loopx
740 Correctx:  Xmax=X
750            Lim=Ymax-Ymin
760            GOSUB Integer_val
770            Y=Ymin+Lim
780            IF Y>=Ymax THEN Correcty
790 Loopy:     Y=Y+I/10
800            IF Y<Ymax THEN Loopy
810 Correcty:  Ymax=Y
820            Xdiff=Xmax-Xmin
830            Ydiff=Ymax-Ymin
840            SCALE Xmin,Xmax,Ymin,Ymax
850            IF (SGN(Xmin)=SGN(Xmax)) OR (Xmin=0) OR (Xmax=0) THEN
860                CALL Intstep(Xdiff,Xstep,Xstepunit)
870            ELSE
880                CALL Intstep(Xmax,Xs1,Xsu1)
890                CALL Intstep(-Xmin,Xs2,Xsu2)
900                Xstep=MIN(Xs1,Xs2)
910                Xstepunit=Xsu1
920                IF Xstep=Xs2 THEN Xstepunit=Xsu2
930            END IF
940            IF (SGN(Ymin)=SGN(Ymax)) OR (Ymin=0) OR (Ymax=0) THEN
950                CALL Intstep(Ydiff,Ystep,Ystepunit)
960            ELSE
970                CALL Intstep(Ymax,Ys1,Ysu1)
980                CALL Intstep(-Ymin,Ys2,Ysu2)
990                Ystep=MIN(Ys1,Ys2)
1000               Ystepunit=Ysu1
1010               IF Ystep=Ys2 THEN Ystepunit=Ysu2
1020           END IF
1030           !
1040           IF A$="BOTH" THEN Bothaxes
1050           IF A$="RIGHT" THEN Rtaxes
1060           IF A$="CENTER" THEN Ctaxes
1070 Lfaxes:   AXES Xstep,Ystep,Xmin,Ymin
1080           SUBEXIT
1090 Rtaxes:   AXES Xstep,Ystep,Xmax,Ymin
1100           SUBEXIT
1110 Bothaxes:AXES Xstep,Ystep,Xmin,Ymin
1120           AXES Xmax-Xmin,Ystep,Xmax,Ymin
1130           SUBEXIT
1140 Ctaxes:   AXES Xstep,Ystep,0,0
1150           SUBEXIT
1160           !
```

```
1170 Integer_val: ! SUBROUTINE Integer_val
1180            I=1
1190            Sign=.1
1200            IF Lim<0 THEN Sign=-.1
1210            Lim=ABS(Lim)
1220 Check_size:IF (Lim>=1) AND (Lim<10) THEN Done
1230            IF Lim>1 THEN Toobig
1240            I=I/10
1250            Lim=Lim*10
1260            GOTO Check_size
1270 Toobig:    I=I*10
1280            Lim=Lim/10
1290            GOTO Check_size
1300 Done:      IF INT(Lim)<>Lim THEN
1310                 Lim=INT(10*Lim)*I*Sign
1320                 IF Sign<0 THEN Lim=Lim+I*Sign
1330            ELSE
1340                 Lim=INT(10*Lim)*I*Sign
1350            END IF
1360            RETURN
1370       SUBEND
1380 !
1390       SUB Check_limits(Error,X1,X2,Y1,Y2)
1400           !
1410            Error=0
1420            IF Y2>Y1 THEN Ydifok
1430            DISP "Ymax < Ymin"
1440            WAIT 3000
1450            GOTO Done
1460 Ydifok:    IF X2>X1 THEN SUBEXIT
1470            DISP "Xmax < Xmin"
1480            WAIT 3000
1490 Done:      Error=1
1500       SUBEND
1510 !
1520       SUB Intstep(Diff,Step,Stepunit)
1530           !
1540            I=1
1550            Step=Diff/10
1560            IF INT(Step)>0 THEN Bignum
1570 Loop1:     I=I/10
1580            Step=Step*10
1590            IF INT(Step)=0 THEN Loop1
1600 Bignum:    IF INT(Step)<10 THEN Cont
1610 Loop2:     I=10*I
1620            Step=Step/10
1630            IF INT(Step)>=10 THEN Loop2
1640 Cont:      Step=INT(Step)
1650            IF (Step=1) OR (Step=2) OR (Step=5) THEN Ok
1660            IF Step=3 THEN Step=2
1670            IF (Step=4) OR (Step=6) OR (Step=7) THEN Step=5
1680            IF (Step=8) OR (Step=9) THEN Step=10
1690 Ok:        Stepunit=Step
1700            Step=Step*I
1710       SUBEND
1720 !
1730       SUB Label_ticks
1740           !
1750            COM Xmin,Xmax,Ymin,Ymax,Xstepunit,Ystepunit,Xstep,Ystep,A$
```

```
1760            SETGU
1770            UNCLIP
1780            MOVE 22,8.5
1790            SETUU
1800            WHERE X,Y
1810            IF A$<>"CENTER" THEN Size
1820            MOVE X,0
1830            SETGU
1840            WHERE X,Y
1850            MOVE X,Y-3.5
1860            SETUU
1870            WHERE X,Y
1880 Size:      CSIZE 3,.5
1890            LORG 4
1900            LDIR 0
1910            LABEL USING "K";Xmin
1920            Num_ticks=INT((Xmax-Xmin)/Xstep)
1930            IF Xstepunit=5 THEN Step51
1940            Num_labels=Num_ticks DIV 5
1950            Step=Xstep*5
1960            GOTO Cont1
1970 Step51:    Num_labels=Num_ticks DIV 2
1980            Step=Xstep*2
1990 Cont1:     FOR J=1 TO Num_labels
2000                SETUU
2010                MOVE X+J*Step,Y
2020                IF (A$="CENTER") AND (Xmin+Step*J=0) THEN Next
2030                LABEL USING "K";Xmin+Step*J
2040 Next:      NEXT J
2050            IF A$="RIGHT" THEN Rtaxes
2060            LORG 7
2070            SETGU
2080            MOVE 20,12
2090            SETUU
2100            WHERE X,Y
2110            Flag=0
2120            IF A$<>"CENTER" THEN Label
2130            MOVE 0,Y
2140            SETGU
2150            WHERE X,Y
2160            MOVE X-2,Y
2170            SETUU
2180            WHERE X,Y
2190            GOTO Label
2200 Rtaxes:    LORG 1
2210            SETGU
2220            MOVE 119,12
2230            SETUU
2240            WHERE X,Y
2250            Flag=1
2260 Label:     LABEL USING "K";Ymin
2270            Num_ticks=INT((Ymax-Ymin)/Ystep)
2280            IF Ystepunit=5 THEN Step52
2290            Num_labels=Num_ticks DIV 5
2300            Step=Ystep*5
2310            GOTO Cont2
2320 Step52:    Num_labels=Num_ticks DIV 2
2330            Step=Ystep*2
2340 Cont2:     FOR J=1 TO Num_labels
```

```
2350                 SETUU
2360                 MOVE X,Y+Step*J
2370                 IF (A$="CENTER") AND (Ymin+Step*J=0) THEN Next1
2380                 LABEL USING "K";Ymin+Step*J
2390 Next1:      NEXT J
2400             IF (Flag=0) AND (A$="BOTH") THEN Rtaxes
2410         SUBEND
2420             !
2430         SUB Label_axes(A$)
2440             !
2450             DIM Hor_label$[30],Ver_label$[30]
2460             SETGU
2470             CSIZE 4,.6
2480             LORG 6
2490             MOVE 70,6
2500             Hor_label$=""
2510             INPUT "'X' axis label",Hor_label$
2520             LABEL USING "K";Hor_label$
2530             IF A$="RIGHT" THEN Rtaxes
2540             MOVE 10,55
2550             LORG 4
2560             GOTO Label
2570 Rtaxes:     MOVE 129,55
2580             LORG 6
2590 Label:      Ver_label$=""
2600             INPUT "'Y' axis label",Ver_label$
2610             LDIR 0,1
2620             LABEL USING "K";Ver_label$
2630             IF A$<>"BOTH" THEN SUBEXIT
2640             MOVE 129,55
2650             LORG 6
2660             LABEL USING "K";Ver_label$
2670         SUBEND
2680 !
2690         SUB Title
2700             !
2710             DIM Plot_title$[60]
2720             SETGU
2730             LDIR 0
2740             CSIZE 4,.6
2750             LORG 4
2760             MOVE 70,93
2770             Plot_title$=""
2780             INPUT "First title line",Plot_title$
2790             LABEL USING "K";Plot_title$
2800             MOVE 70,90
2810             CSIZE 3,.5
2820             Plot_title$=""
2830             INPUT "Second title line",Plot_title$
2840             LABEL USING "K";Plot_title$
2850         SUBEND
2860             !
2870         SUB Info_block(Lineid(*),Numlines,Symbol$,Linesym$(*),Barcht)
2880             !
2890             DIM Id_info$(10)[20]
2900             Plotter=805
2910 Locat:      INPUT "Info block location(UR,LR,UL,LL,NO)",Loc$
2920             IF (Loc$<>"NO") AND (Loc$<>"UR") AND (Loc$<>"LR") AND (Loc$<>"UL")
 AND (Loc$<>"LL") THEN Locat
```

```
2930            IF Loc$="UR" THEN Loc=1
2940            IF Loc$="LR" THEN Loc=2
2950            IF Loc$="UL" THEN Loc=3
2960            IF Loc$="LL" THEN Loc=4
2970            J1=10
2980            IF Loc$="NO" THEN Bar
2990            FOR J=1 TO 10
3000                Id_info$(J)=""
3010                INPUT "Next info block line",Id_info$(J)
3020                IF Id_info$(J)="" THEN J1=J
3030                IF J1=J THEN Bar
3040            NEXT J
3050 Bar:       Barcht=0
3060            DISP "ONE OF 5 PLOTS CAN BE BAR CHART"
3070            WAIT 1000
3080            DISP "MUST BE INCLUDED IN LINE COUNT"
3090            WAIT 1000
3100            INPUT "DO YOU HAVE A BAR CHART?",B$
3110            IF B$[1,1]<>"Y" THEN Cont
3120            INPUT "WHICH LINE NUMBER IS IT?",Barcht
3130            IF (Barcht<1) OR (Barcht>5) THEN Bar
3140 Cont:      Id_info$(J1)="-------------------"
3150            INPUT "No. of lines to be plotted",Numlines
3160            Numlines=INT(Numlines)
3170            IF Barcht>Numlines THEN Bar
3180            IF (Numlines>0) AND (Numlines<6) THEN Lintyp
3190            DISP "Max of 5 lines permitted"
3200            WAIT 5000
3210            GOTO Cont
3220 Lintyp:    GOSUB Linetype
3230            IF Loc$="NO" THEN Sym
3240            FOR J=1 TO Numlines
3250                DISP "Line ";J;" title"
3260                WAIT 2000
3270                INPUT Id_info$(J1+J)
3280                Id_info$(J1+J)=Id_info$(J1+J)[1;15]
3290            NEXT J
3300 Sym:       Symbol$="FALSE"
3310            INPUT "Symbols at data points?",C$
3320            IF C$[1,1]="Y" THEN Symbol$="TRUE"
3330            IF Loc$="NO" THEN SUBEXIT
3340            J2=J1+Numlines+2
3350            ON Loc GOSUB Ur,Lr,Ul,Ll
3360            CSIZE 2.5,.5
3370            LDIR 0
3380            FOR J=1 TO J2-2
3390                LABEL USING "K";Id_info$(J)
3400            NEXT J
3410            GOSUB Smpline
3420            UNCLIP
3430            SUBEXIT
3440          !
3450 Ur:      !  SUBROUTINE Ur
3460            CLIP 88,115,83-J2+2.5,83
3470            SETUU
3480            FRAME
3490            SETGU
3500            LORG 1
3510            X1=109
```

```
3520            Y1=78.75-J1*2.5
3530            MOVE 89,78
3540            RETURN
3550        !
3560 Lr:    !   SUBROUTINE Lr
3570            CLIP 88,115,14,14+J2*2.5
3580            SETUU
3590            FRAME
3600            SETGU
3610            LORG 1
3620            X1=109
3630            Y1=9.75+(J2-J1)*2.5
3640            MOVE 89,9+J2*2.5
3650            RETURN
3660        !
3670 Ul:    !   SUBROUTINE Ul
3680            CLIP 24,51,83-J2*2.5,83
3690            SETUU
3700            FRAME
3710            SETGU
3720            LORG 1
3730            X1=45
3740            Y1=78.75-J1*2.5
3750            MOVE 25,78
3760            RETURN
3770        !
3780 Ll:    !   SUBROUTINE Ll
3790            CLIP 24,51,14,14+J2*2.5
3800            SETUU
3810            FRAME
3820            SETGU
3830            LORG 1
3840            X1=45
3850            Y1=9.75+(J2-J1)*2.5
3860            MOVE 25,9+J2*2.5
3870            RETURN
3880        !
3890 Linetype: !  SUBROUTINE Linetype
3900            Lineid(1)=1
3910            Lineid(2)=4
3920            Lineid(3)=6
3930            Lineid(4)=8
3940            Lineid(5)=3
3950            Linesym$(1)="*"
3960            Linesym$(2)="o"
3970            Linesym$(3)="+"
3980            Linesym$(4)="X"
3990            Linesym$(5)="#"
4000            RETURN
4010        !
4020 Smpline:   !  SUBROUTINE Smpline
4030            SETGU
4040            FOR J=1 TO Numlines
4050                 IF Symbols$="TRUE" THEN OUTPUT Plotter;"SM";Linesym$(J)
4060                 MOVE X1,Y1
4070                 LINE TYPE Lineid(J),5
4080                 IF Lineid(J)=4 THEN LINE TYPE 4,1.5
4090                 IF Lineid(J)=3 THEN LINE TYPE 3,1
4100                 IF Sarcht<>J THEN Draw
```

```
4110                    LORG 2
4120                    LINE TYPE 1
4130                    LABEL USING "K";"BAR"
4140                    GOTO Incr
4150 Draw:              DRAW X1+5,Y1
4160 Incr:              Y1=Y1-2.5
4170                NEXT J
4180                OUTPUT Plotter;"SM"
4190                RETURN
4200            SUBEND
4210                !
4220            SUB Dataentry(Lineid(*),Numlines,Symbol$,Linesym$(*),Barcht)
4230                !
4240                COM Xmin,Xmax,Ymin,Ymax
4250                Plotter=805
4260                SCALE Xmin,Xmax,Ymin,Ymax
4270                SETUU
4280                CSIZE 3,.5
4290                OUTPUT Plotter;"SM"
4300                FOR J=1 TO Numlines
4310                    DISP "ENTER VALUES FOR LINE";J
4320                    WAIT 3000
4330                    IF Barcht<>J THEN Enter
4340                    CALL Barchart
4350                    GOTO Cont
4360 Enter:             INPUT "ENTER 1st POINT <X,Y>",X,Y
4370                    IF Symbol$="TRUE" THEN OUTPUT Plotter;"SM";Linesym$(J)
4380                    MOVE X,Y
4390                    LINE TYPE Lineid(J),3
4400                    IF Lineid(J)=4 THEN LINE TYPE 4,1.5
4410                    IF Lineid(J)=3 THEN LINE TYPE 3,1
4420 Repeat:            INPUT "Next point <X,Y>(-9999 ENDS LINE)",X,Y
4430                    IF X<-9998 THEN Cont
4440                    DRAW X,Y
4450                    GOTO Repeat
4460 Cont:          NEXT J
4470                OUTPUT Plotter;"SM"
4480            SUBEND
4490                !
4500            SUB Datafile(Lineid(*),Numlines,Symbol$,Linesym$(*))
4510                !
4520                COM Xmin,Xmax,Ymin,Ymax
4530                SCALE Xmin,Xmax,Ymin,Ymax
4540                Plotter=805
4550                MASS STORAGE IS ":H7"
4560                SETUU
4570                CSIZE 3,.5
4580            ! PROGRAM OPENS DATA FILE "PLTDAT" FOR DATA
4590            ! ENTRY. THIS MUST BE ON UNIT SPECIFIED
4600            ! BY A MASS STORAGE IS STATEMENT.
4610            ! IT MUST NOT BE A PROTECTED FILE
4620            !       DATA IN FILE MUST BE ORGANIZED
4630            !       AS FOLLOWS:
4640            ! No_pts - VALUE GREATER THAN 1
4650            ! X,Y PAIRS OF No_pts DATA POINTS
4660            ! BEGINNING WITH FIRST CURVE
4670            ! SUBSEQUENT CURVE DATA MUST BEGIN WITH
4680            ! A NEW No_pts VALUE FOR THE CURVE
4690            ! DATA POINTS WILL BE PLOTTED IN THE ORDER
```

```
4700         ! READ SO THEY SHOULD BE IN
4710         ! ORDER OF INCREASING X VALUES.
4720         !
4730          ASSIGN #1 TO "PLTDAT",Return
4740          IF Return=0 THEN Cont
4750          DISP "FILE NOT FOUND OR PROTECTED"
4760          STOP
4770 Cont:    FOR J=1 TO Numlines
4780                LINE TYPE Lineid(J),3
4790                IF Lineid(J)=4 THEN LINE TYPE 4,1.5
4800                IF Lineid(J)=3 THEN LINE TYPE 3,1
4810                IF Symbol$="TRUE" THEN OUTPUT Plotter;"SM";Linesym$(J)
4820 Cont1:         READ #1;No_pts
4830                IF No_pts>1 THEN Cont2
4840                DISP "WRONG NUMBER OF POINTS, LINE";J
4850                WAIT 10000
4860                STOP
4870 Cont2:         READ #1;X,Y
4880                MOVE X,Y
4890                FOR K=2 TO No_pts
4900                      READ #1;X,Y
4910                      DRAW X,Y
4920                NEXT K
4930          NEXT J
4940          OUTPUT Plotter;"SM"
4950     SUBEND
4960         !
4970     SUB Labels
4980         !
4990          DIM Label$[40]
5000          LINE TYPE 1
5010 Redo:    DISP "MOVE PEN TO START OF LABEL,ENTER"
5020          DIGITIZE X,Y
5030          INPUT "ENTER LABEL DIRECTION (DEGREES)",Dir
5040          DEG
5050          LDIR Dir
5060          INPUT "CHARACTER SIZE MULTIPLIER",Size
5070          CSIZE 2.5*Size,.5
5080          LORG 1
5090          INPUT "LABEL",Label$
5100          MOVE X,Y
5110          LABEL USING "K";Label$
5120          INPUT "DO YOU HAVE ANOTHER LABEL?",B$
5130          IF B$[1,1]="Y" THEN Redo
5140     SUBEND
5150         !
5160     SUB Barchart
5170         !
5180          COM Xmin,Xmax,Ymin,Ymax
5190          SCALE Xmin,Xmax,Ymin,Ymax
5200          SETUU
5210          LINE TYPE 1
5220          OUTPUT 805;"SM"
5230 Redo:    INPUT "<HOR> OR <VER> BARS?",Bar$
5240          IF (Bar$<>"HOR") AND (Bar$<>"VER") THEN Redo
5250          INPUT "WIDTH OF BARS",Width
5260          Offset=Width/2
5270          IF Bar$="HOR" THEN Horiz
5280 Vert:    DISP "ENTER Center X, Bar Height"
```

```
5290            WAIT 3000
5300 Next:      INPUT "X,Y (-X ENDS BAR PLOT)",X,Y
5310            IF X<0 THEN SUBEXIT
5320            CLIP X-Offset,X+Offset,Ymin,Y
5330            FRAME
5340            UNCLIP
5350            GOTO Next
5360 Horiz:     DISP "ENTER Bar Length, Center Y"
5370            WAIT 3000
5380 Next1:     INPUT "X,Y (-X ENDS BAR PLOT)",X,Y
5390            IF X<0 THEN SUBEXIT
5400            CLIP Xmin,X,Y-Offset,Y+Offset
5410            FRAME
5420            UNCLIP
5430            GOTO Next1
5440        SUBEND
```

COMMENTS ON PROGRAM "WAVANL"

This program is used to plot curves of wave and ship motion. It takes its input from the 5420A spectrum analyzer and outputs to the 9872B plotter. To work properly the spectrum analyzer should be set up to look at data from 0-32 Hz and the data tape should be run at 16 times normal speed. The data will be converted by the program to the correct range of 0-2 Hz. Using this speed-up greatly reduces the time to analyze the data and causes no loss of accuracy.

The program expects two spectra to be entered. The first must be the wave spectrum if RAO's are required. The second spectrum must be a ship motion corresponding to the wave spectrum. After RUN is pushed the program will wait for the spectra to be input from the analyzer. The data must be sent in ASCII format using "501 SAVE" on the analyzer. The analyzer must be set to addressable only.

Program lines 300 to 380 read the data header. Lines 390 to 410 read the actual data points. The next set of lines correct the wave data to frequency of encounter. Also chosen is the maximum y-value for the plot. This is chosen to be the maximum y-value following the first valley in the spectrum occurring after .05 Hz. This selection criteria will ignore the initial DC spike of the spectrum for scaling purposes.

Note that only the data for the first half of the spectrum is processed. All the useful data occurs between 0 and 1 Hz. Also the frequency range of the wave buoy only extends up to 0.8 Hz.

The motion data is processed in lines 710 to 880. Motion data is already scaled to frequency of encounter so this data needs only to be corrected for tape speed. Two spectra are computed. The first is the input spectrum from the analyzer. The second is the spectrum obtained by integrating the input spectrum twice. This second spectrum will be plotted if heave motion is desired since the input spectrum is heave acceleration. These two spectra have ordinate arrays of Y(2,I) and Y(4,I) respectively. Scaling values are also computed in these lines.

The response amplitude operator's RAO's for these motions are calculated in lines 890 to 1130. Again, two RAO's are computed, one for the input motion and one for the integrated input motion. These are stored in arrays Y(3,I) and Y(5,I) respectively. In order to calculate the RAO's an interpolation between data points is required. This is due to the shift of frequency which occurs when the wave data is converted to frequency of encounter.

The remainder of the program deals with plotting the five spectra developed. Sub-program "Grid" draws the plotting grid with the appropriate labels and title lines. Only roll, pitch and heave motions are implemented together with their RAO's. Wave motion can also be plotted. Sub-program "Plotdata" plots the data on the grid. Line 1820 allows the operator to choose which curve will be plotted. The program will loop to plot as many data curves as desired. Once all data has been plotted the program will again enter a waiting state so that new data can be entered from the analyzer.

Lines 2400 to 2500 show a typical function processing routine, in this case roll. Index is a parameter which determines which of the five spectra will be plotted. An Index=1 indicates wave spectrum, 2 - the motion spectrum, 3 - the RAO spectrum, 4 - the integrated motion spectrum, and 5 - the RAO spectrum for the integrated motion. Subroutine "Size" sets the Y dimension of the plot. The SCALE statement sets the limits of the plot to 0-1 Hz, 0-Maxy where Maxy is chosen in "Size". Axes are then drawn, the tick marks labeled and the axes are labeled. A title and information lines are then added to the plot.

The data is plotted in lines 1330 to 1620. These statements also print the values of the peaks and valleys in the spectrum. Finally, sub-program "Power" is called to integrate the area under the spectrum for all except RAO's. Values for frequencies less than .03 Hz are not integrated.

```
10              ! --  WAVANL  --
20              ! PROGRAM FOR WAVE ANALYSIS
30              ! AT 16 TIMES NORMAL SPEED
40              ! ASSUMES ANALYZER FREQUENCY 0-32 Hz
50              ! THIS CORRESPONDS TO 0-2 Hz REAL TIME
60              ! USE 501 SAVE ON ANALYZER WHEN DATA IS READY
70              ! ENTER WAVE DATA FIRST
80              !
90         COM Y(5,257),X(2,257),X1,X2,Y1,Y2
100        OVERLAP
110        ABORTIO 8
120        RESET 8
130        ON INT #8 CALL Getdata
140        CONTROL MASK 8;128
150        CARD ENABLE 8
160 Wait:GOTO Wait
170  !
180  !
190  ! ******************************
200  !
210  !
220        SUB Getdata
230              COM Y(5,257),X(2,257),X1,X2
240              INTEGER A(12,2),Index,Flag
250              DIM B(4,2),Maxy(5)
260              X(1,257)=X(2,257)=2
270              FOR I=1 TO 5
280                    Y(I,257)=0
290              NEXT I
300              FOR J=1 TO 2
310 Getstat:           STATUS 804;Stat
320                    IF Stat<>96 THEN Getstat
330                    FOR I=1 TO 10
340                          ENTER 804;A(I,J)
350                    NEXT I
360                    FOR I=1 TO 4
370                          ENTER 804;B(I,J)
380                    NEXT I
390                    FOR I=11 TO 12
400                          ENTER 804;A(I,J)
410                    NEXT I
420                    FOR I=1 TO A(3,J)/2
430                          ENTER 804;Y(J,I)
440                    NEXT I
450              NEXT J
460              FOR I=1 TO 5
470                    Maxy(I)=0
480              NEXT I
490              Delta_x1=B(3,1)/16
500              Delta_x2=B(3,2)/16
510              X1=0
520              INPUT "Ship speed in kts",Speed1
530              Speed=Speed1*1.689/32.2
540              INPUT "Heading (180=Head Seas)",Head
550              DEG
560              Factor=COS(Head)
570              Flag=0
580              FOR I=1 TO A(1,1)/4 ! 0-1 Hz
```

```
590                   X1=X1+Delta_1
600                   X(1,I)=X1*(I-X1*6.2832*Speed*Factor
610                   Y(1,I)=16*Y(1,I)/(1-12.5664*X1*Speed*Factor)
620                   IF X1<.05 THEN Next1
630                   Diff=Y(1,I)-Y(1,I-1)
640                   IF (Diff<0) AND (Flag=0) THEN Next1
650                   Flag=1
660                   IF Y(1,I)>Max_y(1) THEN Max_y(1)=Y(1,I)
670 Next1:       NEXT I
680              X2=X(1,A(3,1)/4)
690              Flag=0
700              X(2,0)=0
710              FOR I=1 TO A(3,2)/4! 0-1 Hz
720                   X(2,I)=X(2,I-1)+Delta_x2
730                   Y(2,I)=16*Y(2,I)
740                   Y(4,I)=Y(2,I)/(2*PI*X(2,I))^2
750                   IF X(2,I)<.05 THEN Next
760                   Diff=Y(2,I)-Y(2,I-1)
770                   IF (Diff<0) AND (Flag=0) THEN Next
780                   Flag=1
790                   IF Y(2,I)>Max_y(2) THEN Max_y(2)=Y(2,I)
800 Next:        NEXT I
810              Flag=0
820              FOR I=1 TO A(3,2)/4! 0-1 Hz
830                   IF X(2,I)<.05 THEN Nxt
840                   Diff=Y(4,I)-Y(4,I-1)
850                   IF (Diff<0) AND (Flag=0) THEN Nxt
860                   Flag=1
870                   IF Y(4,I)>Max_y(4) THEN Max_y(4)=Y(4,I)
880 Nxt:         NEXT I
890              I1=Flag=0
900              FOR I=1 TO A(3,2)/4! 0-1 Hz
910 Nxt11:            IF X(1,I1+1)>X(2,I) THEN Cont
920                   I1=I1+1
930                   GOTO Nxt11
940 Cont:             Dd2=(Y(1,I1+1)-Y(1,I1))*(X(2,I)-X(1,I1))
950                   Dd1=Dd2/(X(1,I1+1)-X(1,I1))+Y(1,I1
960                   IF Dd1=0 THEN Dd1=1E-8
970                   Y(3,I)=Y(2,I)/Dd1
980                   Y(5,I)=Y(4,I)/Dd1
990                   IF I1=256 THEN Y(3,I)=Y(5,I)=0
1000                  IF X(2,I)<.05 THEN Nxt12
1010                  Diff=Y(3,I)-Y(3,I-1)
1020                  IF (Diff<0) AND (Flag=0) THEN Nxt12
1030                  Flag=1
1040                  IF Y(3,I)>Max_y(3) THEN Max_y(3)=Y(3,I)
1050 Nxt12:      NEXT I
1060             Flag=0
1070             FOR I=1 TO A(3,2)/4
1080                  IF X(2,I)<.05 THEN Nxt13
1090                  Diff=Y(5,I)-Y(5,I-1)
1100                  IF (Diff<0) AND (Flag=0) THEN Nxt13
1110                  Flag=1
1120                  IF Y(5,I)>Max_y(5) THEN Max_y(5)=Y(5,I)
1130 Nxt13:      NEXT I
1140             Plt=805
1150 Grid:       CALL Grid(Max_y(*),Speed1,Code(*))
1160             CALL Plotdata(A(3,2)/4,Code(*)) 0-1 Hz
1170             INPUT "New plot with this data",C$
```

```
1180          IF C$[1,1]="Y" THEN
1190               Max(1)=Max(1)*1.05
1200               Max(2)=Max(2)*1.05
1210               Max(3)=Max(3)*1.05
1220               GOTO Grid
1230          ELSE
1240               PEN 0
1250          END IF
1260          CARD ENABLE 8
1270     SUBEND
1280 !
1290 !
1300 ! ******************************
1310 !
1320 !
1330     SUB Plotdata(Numpoints,INTEGER Index)
1340          COM Y(5,257),X(2,257),X1,X2,Y1,Y2
1350          CLIP 14,112,14,86
1360          SETUU
1370          SCALE X1,X2,Y1,Y2
1380          MOVE 0,Y(Index,1)
1390          Indl=Index
1400          IF Index>2 THEN Indl=2
1410          Difl=Y(Index,1)
1420          I1=1
1430          FOR I=2 TO Numpoints
1440               Dif=Difl
1450               Difl=Y(Index,I)-Y(Index,I-1)
1460               IF SGN(Dif)<>SGN(Difl) THEN
1480                    IF (ABS((Y(Index,I-1)-Y(Index,I1))/Y2)>.05) OR (Y(Index,
I-1)>.1*Y2) THEN
1490                         PRINT USING For;X(Indl,I-1),Y(Index,I-1)
1500                         I1=I-1
1510                    END IF
1530               ELSE
1540                    IF (I-1) MOD 10=0 THEN
1550                         PRINT USING For;X(Indl,I-1),Y(Index,I-1)
1560                    END IF
1570               END IF
1580               DRAW X(Indl,I),Y(Index,I)
1590          NEXT I
1600 For:     IMAGE 14X,MD.DDDDDD,20X,MD.DDDDDDE
1610          CALL Power(Numpoints,Index)
1620     SUBEND
1630 !
1640 !
1650 ! ******************************
1660 !
1670 !
1680     SUB Grid(Ymax(*),Speed1,INTEGER Index)
1690          COM Y(5,257),X(2,257),Xmin,Max,Ymin,Max
1700          INTEGER Botlin
1710          Plter=805
1720          PLOTTER IS 8,5,"9872A"
1730          DISP "Put paper on plotter, PUSH CONT"
1740          PAUSE
1750          LIMIT 30,208,30,173
1760          LOCATE 14,112,14,86
```

```
1770            SETUU
1780            PEN 1
1790            FRAME
1800            CLIP 13,113,13,87
1810            Xmin=Ymin=0
1820 Renter:  INPUT "ROLL 1,WAVE=2,ROLL RAO=3,PITCH=4,PITCH RAO=5,HEAVE=6,HEAVE
RAO=7",Borlin
1830            IF (Borlin<1) OR (Borlin>7) THEN Renter
1840            FOR I=1 TO 5
1850                Ymax(I)=Ymax(I)*1.05
1860            NEXT I
1870            ON Borlin GOTO Roll,Wave,Rrao,Pitch,Prao,Heave,Hrao
1880 !
1890 !
1900 ! *******************************
1910 !
1920 !
1930 Size:  ! SUBROUTINE TO DETERMINE ORDINATE SIZE
1940 !
1950            I=1
1960 Check_size:IF (Maxy>=1) AND (Maxy<10) THEN Done
1970            IF Maxy<1 THEN Toobig
1980            I=I/10
1990            Maxy=Maxy*10
2000            GOTO Check_size
2010 Toobig:    I=I*10
2020            Maxy=Maxy/10
2030            GOTO Check_size
2040 Done:      Maxy=INT(Maxy)*I
2050            IF Maxy>Ymax(Index) THEN Correcty
2060 Loopy:     Maxy=Maxy+I/10
2070            IF Maxy<Ymax(Index) THEN Loopy
2080 Correcty:GOSUB Intstep
2090            RETURN
2100 !
2110 !
2120 ! -------------------------------
2130 !
2140 !
2150 Intstep:   ! SUBROUTINE Intstep
2160 !
2170            I=1
2180            Step=Maxy/10
2190            IF INT(Step)>0 THEN Signum
2200 Loop1:     I=I/10
2210            Step=Step*10
2220            IF INT(Step)=0 THEN Loop1
2230 Signum:    IF INT(Step)<10 THEN Cont
2240 Loop2:     I=10*I
2250            Step=Step/10
2260            IF INT(Step)>=10 THEN Loop2
2270 Cont:      Step=INT(Step)
2280            IF (Step=1) OR (Step=2) OR (Step=5) THEN Ok
2290            IF Step=3 THEN Step=2
2300            IF (Step=4) OR (Step=6) OR (Step=7) THEN Step=5
2310            IF (Step=8) OR (Step=9) THEN Step=10
2320 Ok:        Stepunit=Step
2330            Step=Step*I
2340            RETURN
2350 !
```

```
2360 !
2370 ! ------------------------------
2380 !
2390 !
2400 Roll:      Maxy=Ymax(2)
2410            Index=2
2420            GOSUB Size
2430            SCALE 0,1,0,Maxy
2440            AXES .1,Step
2450            Maxx=1
2460            CALL Label_ticks(Maxx,Maxy,Stepunit,Step)
2470            CALL Label_axes("ROLL")
2480            CALL Title(Botlin)
2490            CALL Info(Speed1)
2500            SUBEXIT
2510 Wave:      Maxy=Ymax(1)
2520            Index=1
2530            GOSUB Size
2540            Maxx=INT(Maxx+1.1)
2550            IF Maxx<1 THEN Maxx=1
2560            SCALE 0,Maxx,0,Maxy
2570            IF Maxx<=2 THEN
2580                 AXES .1,Step
2590            ELSE
2600                 AXES .5,Step
2610            END IF
2620            CALL Label_ticks(Maxx,Maxy,Stepunit,Step)
2630            CALL Label_axes("WAVE")
2640            CALL Title(Botlin)
2650            CALL Info(Speed1)
2660            SUBEXIT
2670 Prao:      Maxy=Ymax(3)
2680            Index=3
2690            GOSUB Size
2700            SCALE 0,1,0,Maxy
2710            AXES .1,Step
2720            Maxx=1
2730            CALL Label_ticks(Maxx,Maxy,Stepunit,Step)
2740            CALL Label_axes("PRAO")
2750            CALL Title(Botlin)
2760            CALL Info(Speed1)
2770            SUBEXIT
2780 Pitch:     Maxy=Ymax(2)
2790            Index=2
2800            GOSUB Size
2810            SCALE 0,1,0,Maxy
2820            AXES .1,Step
2830            Maxx=1
2840            CALL Label_ticks(Maxx,Maxy,Stepunit,Step)
2850            CALL Label_axes("PITCH")
2860            CALL Title(Botlin)
2870            CALL Info(Speed1)
2880            SUBEXIT
2890 Prao:      Maxy=Ymax(3)
2900            Index=3
2910            GOSUB Size
2920            SCALE 0,1,0,Maxy
2930            AXES .1,Step
2940            Maxx=1
```

```
2950              CALL Label_ticks(Maxx,Maxy,Stepunit,Step)
2960              CALL Label_axes("FRAO")
2970              CALL Title(Botlin)
2980              CALL Info(Speed1)
2990              SUBEXIT
3000 Heave:       Maxy=Ymax(4)
3010              Index=4
3020              GOSUB Size
3030              SCALE 0,1,0,Maxy
3040              AXES .1,Step/
3050              Maxx=1
3060              CALL Label_ticks(Maxx,Maxy,Stepunit,Step)
3070              CALL Label_axes("HEAVE")
3080              CALL Title(Botlin)
3090              CALL Info(Speed1)
3100              SUBEXIT
3110 Hrao:        Maxy=Ymax(5)
3120              Index=5
3130              GOSUB Size
3140              SCALE 0,1,0,Maxy
3150              AXES .1,Step
3160              Maxx=1
3170              CALL Label_ticks(Maxx,Maxy,Stepunit,Step)
3180              CALL Label_axes("HRAO")
3190              CALL Title(Botlin)
3200              CALL Info(Speed1)
3210          SUBEND
3220 !
3230 !
3240 ! ******************************
3250 !
3260 !
3270          SUB Label_ticks(Maxx,Maxy,Unit,Step)
3280              SETGU
3290              UNCLIP
3300              MOVE 14,10.5
3310              SETUU
3320              WHERE X,Y
3330              CSIZE 3,.5
3340              LORG 4
3350              LDIR 0
3360              LABEL USING "K";"0"
3370              Num_ticks=INT(Maxx*10)
3380              IF Num_ticks<20 THEN
3390                  FOR J=1 TO Num_ticks
3400                      MOVE X+J/10,Y
3410                      LABEL USING "K";J/10
3420                  NEXT J
3430              ELSE
3440                  FOR J=1 TO Num_ticks
3450                      MOVE X+J/10,Y
3460                      IF J MOD 10=0 THEN LABEL USING "K";J/10
3470                  NEXT J
3480              END IF
3490              LORG 7
3500              SETGU
3510              MOVE 12,14
3520              SETUU
3530              WHERE X,Y
```

```
3540          LABEL USING "K";"0"
3550          Num_ticks=INT(Max/Step)
3560          IF Unit=5 THEN Step5
3570          Num_labels=Num_ticks DIV 5
3580          Step=Step*5
3590          GOTO Cont
3600 Step5:   Num_labels=Num_ticks DIV 2
3610          Step=Step*2
3620 Cont:    IF Step>.001 THEN
3630               FOR J=1 TO Num_labels
3640                    MOVE X,Y+Step*J
3650                    LABEL USING "K";Step*J
3660               NEXT J
3670          ELSE
3680               DEG
3690               LORG 4
3700               CSIZE 3,.35
3710               LDIR 90
3720               FOR J=1 TO Num_labels
3730                    MOVE X,Y+Step*J
3740                    LABEL USING "D.DE";Step*J
3750               NEXT J
3760          END IF
3770      SUBEND
3780 !
3790 !
3800 ! ****************************
3810 !
3820 !
3830      SUB Label_axes(A$)
3840          Pltr=805
3850          SETGU
3860          OUTPUT Pltr;"SI.15,.3"
3870          LDIR 0
3880          CSIZE 3
3890          LORG 4
3900          MOVE 67,7
3910          LABEL USING "K";"FREQUENCY OF ENCOUNTER  (Hz)"
3920          MOVE 5,38
3930          CSIZE 4,.5
3940          OUTPUT Pltr;"DI0,1"
3950          IF A$<>"ROLL" THEN Notroll
3960          OUTPUT Pltr;"LB23"
3970          OUTPUT Pltr;"UC99,0,3,1,2,2,0,1,-2,0,-3,-1,-2,-2,0,-1,2,-99,1,-5,9
9,2,13"
3980          OUTPUT Pltr;"LS(f) Deg"
3990          OUTPUT Pltr;"UC-99,2,6,99,-2,0,2,4,0,2,-1,1,-1,-1"
4000          OUTPUT Pltr;"LB-sec"
4010          SETGU
4020          MOVE 63,3
4030          LORG 6
4040          LDIR 0
4050          CSIZE 4,.6
4060          LABEL USING "K";"ROLL ENERGY SPECTRUM"
4070          SUBEXIT
4080 Notroll: IF A$<>"WAVE" THEN Notwave
4090          OUTPUT Pltr;"LB23"
4100          OUTPUT Pltr;"UC-99,0,-5,99,2,0,1,2,0,1,-1,2,-1,0,-1,1,0,4,1,1,1,0,
1,-1,-1,-1,-1,2,0,1"
```

```
4110            OUTPUT Pltr;"LB(f)  Ft"
4120            OUTPUT Pltr;"UC-99,2,6,99,-2,0,2,4,0,2,-1,1,-1,-1"
4130            OUTPUT Pltr;"LB-sec"
4140            SETGU
4150            MOVE 63,3
4160            LORG 6
4170            LDIR 0
4180            CSIZE 4,.6
4190            LABEL USING "K";"WAVE ENERGY SPECTRUM"
4200            SUBEXIT
4210 Notwave:   IF A$<>"FRAO" THEN Notrao
4220            OUTPUT Pltr;"LBY"
4230            OUTPUT Pltr;"UC99,0,3,1,2,2,0,1,-2,0,-3,-1,-2,-2,0,-1,2,-99,1,-5,9
9,2,13"
4240            OUTPUT Pltr;"UC-99,0,-5,99,2,0,1,2,0,1,-1,2,-1,0,-1,1,0,4,1,1,1,0,
1,-1,-1,-1,-1,2,0,1"
4250            OUTPUT Pltr;"LB(F) = ("
4260            OUTPUT Pltr;"UC-99,0,3,99,0,3,1,2,2,0,1,-2,0,-3,-1,-2,-2,0,-1,2,-9
9,1,-5,99,2,13"
4270            OUTPUT Pltr;"LB "
4280            OUTPUT Pltr;"UC-99,0,-1,99,2,0,1,2,0,1,-1,2,-1,0,-1,1,0,4,1,1,1,0,
1,-1,-1,-1,-1,2,0,1"
4290            OUTPUT Pltr;"LB)"
4300            OUTPUT Pltr;"UC-99,2,6,99,-2,0,2,4,0,2,-1,1,-1,-1"
4310            SETGU
4320            MOVE 63,3
4330            LORG 6
4340            LDIR 0
4350            CSIZE 4,.6
4360            LABEL USING "K";"ROLL RESPONSE AMPLITUDE OPERATOR"
4370            SUBEXIT
4380 Notrao:    IF A$<>"PITCH" THEN Notpitch
4390            OUTPUT Pltr;"LB2S"
4400            OUTPUT Pltr;"UC-99,0,1,99,0,2,1,2,1,0,1,-2,0,-4,-1,-2,-1,0,-1,2,0,
2,3,0"
4410            OUTPUT Pltr;"LB(f) Deg"
4420            OUTPUT Pltr;"UC-99,2,6,99,-2,0,2,4,0,2,-1,1,-1,-1"
4430            OUTPUT Pltr;"LB-sec"
4440            SETGU
4450            MOVE 63,3
4460            LORG 6
4470            LDIR 0
4480            CSIZE 4,.6
4490            LABEL USING "K";"PITCH ENERGY SPECTRUM"
4500            SUBEXIT
4510 Notpitch:IF A$<>"FRAO" THEN Notprao
4520            OUTPUT Pltr;"LBY"
4530            OUTPUT Pltr;"UC-99,0,1,99,0,2,1,2,1,0,1,-2,0,-4,-1,-2,-1,0,-1,2,0,
2,3,0"
4540            OUTPUT Pltr;"UC-99,0,-5,99,2,0,1,2,0,1,-1,2,-1,0,-1,1,0,4,1,1,1,0,
1,-1,-1,-1,-1,2,0,1"
4550            OUTPUT Pltr;"LB(F) = ("
4560            OUTPUT Pltr;"UC-99,0,5,99,0,2,1,3,2,0,1,-3,0,-4,-1,-3,-2,0,-1,3,0,
2,4,0"
4570            OUTPUT Pltr;"LB "
4580            OUTPUT Pltr;"UC-99,0,-1,99,2,0,1,2,0,1,-1,2,-1,0,-1,1,0,4,1,1,1,0,
1,-1,-1,-1,-1,2,0,1"
4590            OUTPUT Pltr;"LB)"
4600            OUTPUT Pltr;"UC-99,2,6,99,-2,0,2,4,0,2,-1,1,-1,-1"
```

```
4610            SETGU
4620            MOVE 63,3
4630            LORG 6
4640            LDIR 0
4650            CSIZE 4,.6
4660            LABEL USING "K";"PITCH RESPONSE AMPLITUDE OPERATOR"
4670            SUBEXIT
4680 Notprao:   IF A$<>"HEAVE" THEN Nothev
4690            OUTPUT Pltr;"LB2S"
4700            OUTPUT Pltr;"UC-99,0.5,99,3,0,-3,-3,3,0,-99,-2,4,99,1,0"
4710            OUTPUT Pltr;"LB(f) Ft"
4720            OUTPUT Pltr;"UC-99,2,6,99,-2,0,2,4,0,2,-1,1,-1,-1"
4730            OUTPUT Pltr;"LB-sec"
4740            SETGU
4750            MOVE 63,3
4760            LORG 6
4770            LDIR 0
4780            CSIZE 4,.6
4790            LABEL USING "K";"HEAVE ENERGY SPECTRUM"
4800            SUBEXIT
4810 Nothev:    OUTPUT Pltr;"LBY"
4820            OUTPUT Pltr;"UC-99,0.5,99,3,0,-3,-3,3,0,-99,-2,4,99,1,0"
4830            OUTPUT Pltr;"UC-99,0,-5,99,2,0,1,2,0,1,-1,2,-1,0,-1,1,0,4,1,1,1,0,
1,-1,-1,-1,-1,2,0,1"
4840            OUTPUT Pltr;"LB(f) = (Z)"
4850            OUTPUT Pltr;"UC-99,0,-1,99,2,0,1,2,0,1,-1,2,-1,0,-1,1,0,4,1,1,1,0,
1,-1,-1,-1,-1,2,0,1"
4860            OUTPUT Pltr;"LB)"
4870            OUTPUT Pltr;"UC-99,2,6,99,-2,0,2,4,0,2,-1,1,-1,-1"
4880            SETGU
4890            MOVE 63,3
4900            LORG 6
4910            LDIR 0
4920            CSIZE 4,.6
4930            LABEL USING "K";"HEAVE RESPONSE AMPLITUDE OPERATOR"
4940       SUBEND
4950 !
4960 !
4970 ! ******************************
4980 !
4990 !
5000       SUB Title(INTEGER Code)
5010            DIM Plot_title$[60]
5020            PRINTER IS 0,23
5030            PRINT PAGE
5040            SETGU
5050            LDIR 0
5060            CSIZE 4,.6
5070            LORG 4
5080            MOVE 63,93
5090            Plot_title$="USCGC DORADO (WEB-1)"
5100            LABEL USING "K";Plot_title$
5110            PRINT TAB(20),Plot_title$,LIN(1)
5120            MOVE 63,90
5130            CSIZE 3,.5
5140            Plot_title$=""
5150            INPUT "DATE",Date$
5160            Plot_title$="Tested ";Date$
5170            LABEL USING "K";Plot_title$
```

```
5180          SELECT Code
5190          CASE 1
5200               PRINT TAB(20),"Full Energy Spectrum"
5210          CASE 2
5220               PRINT TAB(20),"Wave Energy Spectrum"
5230          CASE 3
5240               PRINT TAB(13),"Roll Response Amplitude Operator"
5250          CASE 4
5260               PRINT TAB(19),"Pitch Energy Spectrum"
5270          CASE 5
5280               PRINT TAB(13),"Pitch Response Amplitude Operator"
5290          CASE 6
5300               PRINT TAB(19),"Heave Energy Spectrum"
5310          CASE 7
5320               PRINT TAB(13),"Heave Response Amplitude Operator"
5330          END SELECT
5340          PRINT TAB(23),Plot_title$
5350     SUBEND
5360 !
5370 !
5380 ! ********************************
5390 !
5400 !
5410     SUB Info(S)
5420          DIM Data$[20]
5430          SETGU
5440          LDIR 0
5450          CSIZE 3,.5
5460          LORG 1
5470          MOVE 72,81
5480          INPUT "Run no.",Data$
5490          LABEL USING Run;Data$
5500 Run:     IMAGE "Run No.       ",3A
5510          PRINT LIN(1),"              Run No. ";Data$;
5520          INPUT "SEAS",Data$
5530          LABEL USING "20A";Data$
5540          PRINT ", Speed ";S;", SEAS-";Data$,LIN(1)
5550          PRINT "           FREQUENCY OF ENCOUNTER                    AMPLITUDE"
5560          LABEL USING Speed;S
5570 Speed:   IMAGE "Speed        ",DD.D," kts"
5580          INPUT "CALIBRATION",Data$
5590          IF Data$="0" THEN SUBEXIT
5600          LABEL USING Cal;Data$
5610 Cal:     IMAGE "Calibration ",7A
5620     SUBEND
5630 !
5640 !
5650 ! ********************************
5660 !
5670 !
5680     SUB Power(Numpoints,INTEGER Inde)
5690          COM Y(5,257),X(2,257)
5700          IF (Inde =2) OR (Inde =5) THEN SUBEXIT
5710          Indl=Inde
5720          IF Inde>=4 THEN Indl=2
5730          Sum=0
5740          FOR I=1 TO Numpoints
5750               IF X(Indl,I)<.03 THEN Next
5760               Sum=Sum+Y(Inde,I)*(X(Indl,I+1)-X(Indl,I))
```

```
5770 Nexti:    NEXT I
5780           SETGU
5790           CSIZE 4,.5
5800           LORG 5
5810           LDIR 0
5820           MOVE 80,90
5830           LABEL USING Pow;Sum
5840 Pow:      IMAGE "Energy = ",DDD.DDD
5850      SUBEND
5860           END
```

COMMENTS ON PROGRAM "WAVHGT"

This program was used to measure the instantaneous voltage of a motion signal and then determine the peak voltage of the wave form. The heights between successive peaks was then calculated and stored in the array "Height". This array is then sorted beginning with the highest values. The sorted list is then used to determine the average 1/3 and 1/10 highest motions.

Although the name implies that this program deals with wave heights, it may be used with any motion provided the correct scale factor is inserted at line 130. "Attn" is the multiplying factor to convert voltage to the motion units.

The DC offset in line 110 may have to be changed for each run to insure the signal is reasonably well centered about zero volts. A peak will be ignored if it is on the same side of zero volts as the last peak or if the voltage of the peak is within ± "Epsilon" volts of zero.

Tape speed should be 8 to 16 times the original speed when using this program. Lower speeds will not cause a problem but will take longer to run. Higher speeds will reduce the accuracy in determining the peaks.

```
10        PRINTER IS 0,20
20    ! PROGRAM NAME "WAVHGT"
30    !
40    ! ANALYSES WAVE HEIGHT AND SHIP MOTION AMPLITUDE
50    ! TO DETERMINE 1/3 AND 1/10 HIGHEST MOTIONS
60    ! USES SPECIAL FUNCTION KEY #0 TO STOP INPUT OF DATA
70    ! SHOULD BE RUN AT 8-16 TIMES ORIGINAL SPEED
80    !
90        OPTION BASE 1
100       DIM Height(900),Id$[80]
110       Offset=.15           ! DC offset in signal
120       Epsilon=.05          ! Band width about 0 in which peak ignored
130       Attn=18              ! Tape attn X units conversion
140       INPUT "RUN ID",Id$
150       DISP "STANDING BY TO START"
160       PAUSE
170       Old_peak=Index=0
180       ON KEY #0 GOTO Input_complete
190       DISP "PUSH KEY #0 TO STOP INPUT"
200       OVERLAP
210       OUTPUT 824;"D.003S,N1S,E0S,R2,T2,F1"
220       TRIGGER 824
230       ENTER 824;Prev_reading
240       TRIGGER 824
250       ENTER 824;Current_reading
260       Difference=Current_reading-Prev_reading
270       Prev_reading=Current_reading
280 Repeat:TRIGGER 824
290       ENTER 824;Current_reading
300       New_difference=Current_reading-Prev_reading
310       IF SGN(New_difference)<>SGN(Difference) THEN Peak
320       Difference=New_difference
330       Prev_reading=Current_reading
340       GOTO Repeat
350 Peak:New_peak=Prev_reading
360       Difference=New_difference
370       Prev_reading=Current_reading
380       IF Old_peak=0 THEN Firstpk
390       IF SGN(Old_peak-Offset)=SGN(New_peak-Offset) THEN Repeat
400       IF ABS(New_peak-Offset)<Epsilon THEN Repeat
410       Index=Index+1
420       Height(Index)=ABS(New_peak-Old_peak)*Attn
430 Firstpk:Old_peak=New_peak
440       GOTO Repeat
450   !
460 Input_complete:   !
470       DISP "KEY #0 PUSHED"
480       REDIM Height(Index)
490       CALL Sort(Height(*),1,Index)
500       CALL Tenth_avg(Height(*),Index,Avg_10th)
510       CALL Third_avg(Height(*),Index,Avg_3rd)
520       PRINT PAGE,Id$
530       PRINT LIN(1),"Average 1/10 highest = ";Avg_10th
540       PRINT "Average  1/3 highest = ";Avg_3rd
550       PRINT "A total of ";Index;" heights were measured",LIN(1)
560       PRINT "Measured heights are:",LIN(1)
570       PRINT Height(*),
580       END
590          !
600          !
```

```
610       SUB Sort(A(*),I1,J1)
620           N=J1+1-I1
630           Logtwo=INT(LGT(N)/LGT(2))+1
640           CALL Qsort(A(*),Logtwo,I1,J1)
650           SUBEXIT
660   !
670       SUB Qsort(A(*),Log,I1,J1)
680           OPTION BASE 1
690           DIM L(Log),U(Log)
700           M=1
710           I=I1
720           J=J1
730 Start1:   IF I>=J THEN Nextgroup
740 Start2:   K=1
750           I2=INT((J+I)/2)
760           T=A(I2)
770 I1:       IF A(I)>=T THEN Lowmiddle1
780           A(I2)=A(I)
790           A(I)=T
800           T=A(I2)
810 Lowmiddle1:L=J
820 I2:       IF A(J)<=T THEN Middlehigh
830           A(I2)=A(J)
840           A(J)=T
850           T=A(I2)
860 I3:       IF A(I)>=T THEN Middlehigh
870           A(I2)=A(I)
880           A(I)=T
890           T=A(I2)
900 Middlehigh:L=L-1
910 I4:       IF A(L)<T THEN Middlehigh
920           T1=A(L)
930 Stepup:   K=K+1
940 I5:       IF A(K)>T THEN Stepup
950           IF K>L THEN Passed
960           A(L)=A(K)
970           A(K)=T1
980           GOTO Middlehigh
990 Passed:   IF L-I<=J-K THEN Storehigh
1000          L(M)=I
1010          U(M)=L
1020          I=K
1030          M=M+1
1040          GOTO Cont
1050 Storehigh:L(M)=K
1060          U(M)=J
1070          J=L
1080          M=M+1
1090 Cont:    IF J-I>=11 THEN Start2
1100          IF I=I1 THEN Start1
1110          I=I-1
1120 Inc:     I=I+1
1130          IF I=J THEN Nextgroup
1140          T=A(I+1)
1150 I6:      IF A(I)>=T THEN Inc
1160          K=I
1170 Copy:    A(K+1)=A(K)
1180          K=K-1
1190 I7:      IF T>A(K) THEN Copy
```

```
1200            A(K+1)=T
1210            GOTO Inc
1220 Nextgroup:M=M-1
1230            IF M=0 THEN Out
1240            I=L(M)
1250            J=U(M)
1260            GOTO Cont
1270 Out:       SUBEXIT
1280 !
1290      SUB Tenth_avg(A(*),Index,Avg_10th)
1300            J=INT(Index/10)
1310            Avg_10th=0
1320            IF J=0 THEN SUBEXIT
1330            FOR I=1 TO J
1340                  Avg_10th=Avg_10th+A(I)/J
1350            NEXT I
1360      SUBEND
1370 !
1380      SUB Third_avg(A(*),Index,Avg_3rd)
1390            J=INT(Index/3)
1400            Avg_3rd=0
1410            IF J=0 THEN SUBEXIT
1420            FOR I=1 TO J
1430                  Avg_3rd=Avg_3rd+A(I)/J
1440            NEXT I
1450      SUBEND
```

APPENDIX C
RECOMMENDATIONS FOR IMPROVING TEST PROCEDURES AND EQUIPMENT

RECOMMENDATIONS FOR IMPROVING TEST PROCEDURES AND EQUIPMENT

Four areas where improvement is necessary will be discussed in this appendix. These are improvements in the use of questionnaires, improvements in measuring speed, improvements in measuring the directionality of wave spectra and improvements in the method of measuring shaft torque. The last will be considered first.

Shaft torque and hence shaft horsepower (HP) were measured during the DORADO tests using a powerometer developed by Ultra Products Systems. This device was found to have serious drawbacks although in concept it represents a significant improvement over husk type torsion measuring devices. These require slip rings or telemetry to get the signal off the rotating shaft. In the powerometer concept two prerecorded tapes are wrapped around the shaft and a carriage with tape playback heads is secured to ride on the shaft with the playback heads over the tapes. The signal from each tape is fed to the powerometer for processing.

The tapes applied to the shaft each have a sine wave recorded on them. The sine waves of the two tapes are identical in frequency. The tapes are applied 15 inches apart on the shaft and as the shaft twists from torque loading the relative phase angle of the sine waves will change. It is this change in phase angle that is used to compute the torque. The frequency of the sine wave is proportional to the RPM of the shaft. These two values are used to compute HP.

When conditions are ideal this works fine. In the DORADO tests the tape sets supplied by Ultra Products Systems were not of identical frequency. The difference in frequency was less than one percent but this was more than sufficient to disrupt the measuring process. Without an identical frequency the phase angle is different for each cycle of the sine wave. Also the tape must be handled very delicately to prevent stretching. Even a minute stretch will change the phase angle locally.

By a great deal of post processing it was possible to extract the torque information. However, the problems of tape stretch and non-identical frequencies must be solved if the device is to be used satisfactorily. The best solution is for us to record our own tapes. This will require purchase of a high quality frequency generator which has a near zero drift in frequency. Also, tape material should be investigated to see if there is a material on the market which will eliminate the stretching problem.

The powerometer is capable of only one HP calculation in 15-20 seconds. This may not satisfy the needs of the test. Near instantaneous torque values can be obtained using a dual channel spectrum analyzer. By putting the signal from each playback head into a separate channel the phase angle between the signals can be measured directly. More accurate values of torque could be obtained by recording sine waves of many different frequencies on each tape. The phase angle shift at each frequency can be determined using the spectrum analyzer. The torques determined using each frequency can be averaged to improve the variance.

The wave directionality problem is more difficult because the R&D Center is currently using a state-of-the-art approach. A waverider buoy is used to determine a point spectrum for the sea waves. This spectrum contains no information on wave direction. The ship is operated on different headings to the sea after the principal wave direction is determined by eye. This method of determining wave direction is imprecise at best and is impossible if there are significant waves coming from multiple directions as is usually the case. The resulting ship motions are not reproducible in different seaways having the same spectrum but different directionality.

A different method for measuring wave height is proposed to markedly improve on this problem. For many years the Navy has used sensors mounted to the bow of the ship to measure wave height. Single sensors are used and only a point spectrum is obtained. However, with a sensor on the vessel the wave measured is the wave actually encountered and no correction need be made for ship speed or direction to the waves. Also, any spatial change in the wave energy spectrum will no longer cause a problem because the wave energy is measured at the ship.

Typical sensors used include radar and laser altimeters and sonic height sensors. The radar altimeters appear to be best. All require that the height be corrected for ship motion which introduces a new source of errors.

It is proposed that this method be carried one step further to obtain wave directionality. Two height sensors can be used spaced a fixed distance apart. The height signal from each sensor can be fed into a separate channel of a dual-channel spectrum analyzer. This analyzer can determine the cross power spectrum of the signals rather than the auto power spectrum of each signal individually as is now done.

The usefulness of the cross power spectrum lies in the fact that the spectrum represents the apparent wave propagation along the line of the two sensors. Figure C-1 shows how an array of five sensors could be arranged to measure the spectrum each 22-1/2 degrees around the horizon. The sensors are used in pairs to do this. By choosing the pair of sensors most appropriate to the motion being measured, the primary directional spectrum driving that motion can be determined. For example, two sensors in line with the longitudinal axis would be used to evaluate pitch response. This should significantly improve the repeatability of response amplitude operators and permit extension to other sea states. At the very least the directional spectrum of the sea could be determined with high accuracy.

The array of sensors would be mounted to the vessel's bow. As before, corrections must be made for vessel motion. The spectrum analyzer requires an analog input signal. Therefore, the outputs of the sensor package must be analog.

This appears to be a promising approach to measuring wave spectra but needs to be developed more and tested under field conditions before being adopted. The spacing between sensors is the primary variable to be studied.

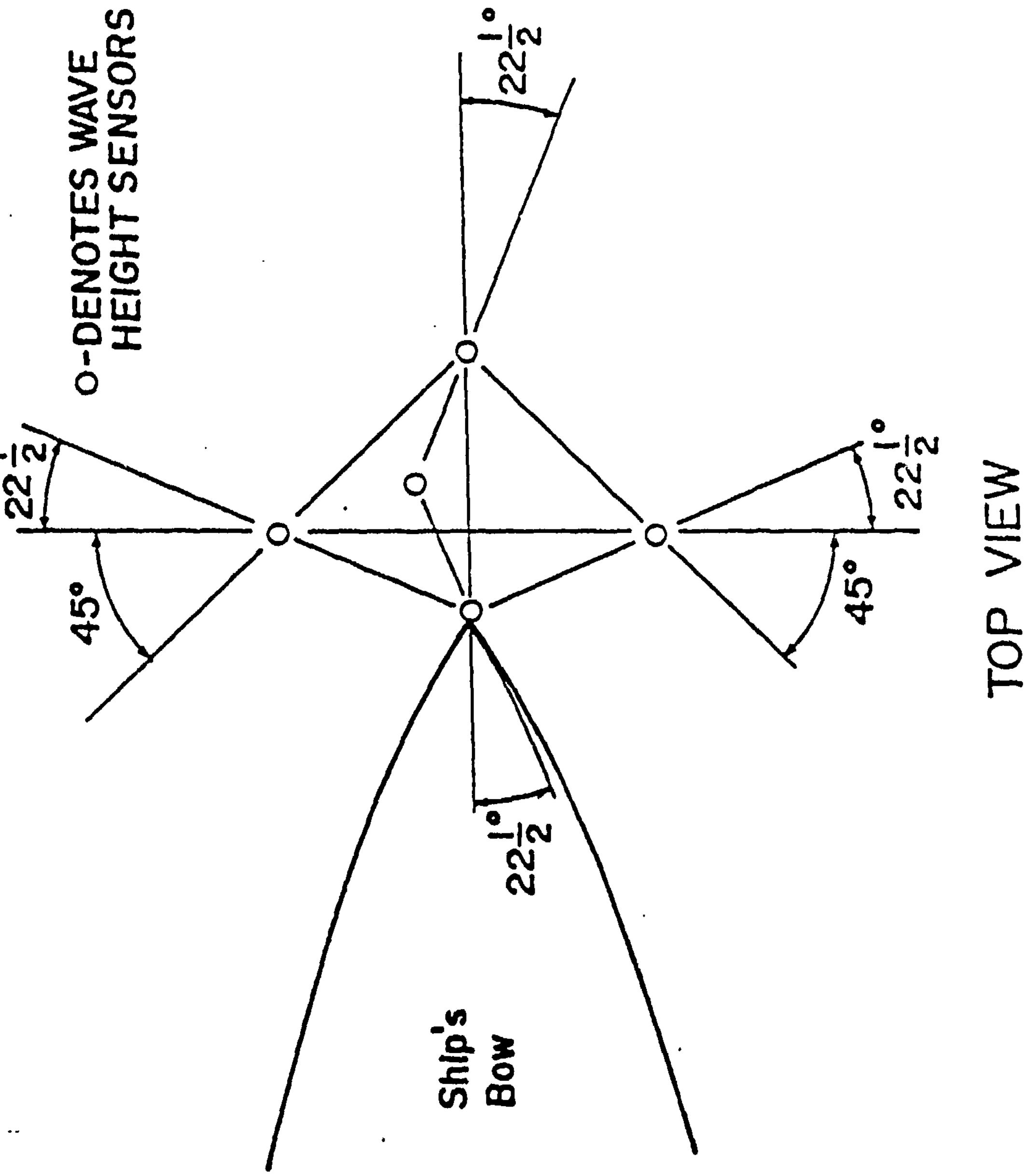


Figure C-1
POSSIBLE WAVE SENSOR ARRANGEMENT

The current method for measuring vessel speed involves the use of Loran-C. The time to travel between two Loran-C positions and the distance between these positions provides the data necessary for the speed calculations. This has proved quite accurate and precise for measuring average speed over about a 2-mile course; however, no information is available on instantaneous speed or side slip relative to the water.

Most speed sensors commercially available require installation through the hull. This is unacceptable for most ship tests. At the Sixth Ship Control Systems Symposium in Ottawa, Ontario, Canada, Samuel Cheney presented a paper entitled "High Speed Velocity Log, A Practical Solution for Precise Speed and Sideslip Measurement for Air Cushion Vehicles." This paper describes a Doppler radar approach to vessel speed measurement developed by the Naval Air Development Center. The sensor described appears to be a significant improvement over the Loran-C method currently used and does not require through-hull mounting. Side slip speed is also available. The sensor mounts on the bow of the test vessel near the deck. An effort should be made to obtain a similar sensor package for AMV testing use. The one disadvantage of this sensor is that testing must be done when winds are greater than 5 knots or seas greater than 6 inches. The sensor will not work in flat calm conditions.

The present concept for using questionnaires to obtain information during an OPEVAL has some serious drawbacks. These were emphasized during the DORADO tests. The concept of using questionnaires requires two essential elements. First the people filling out the questionnaires must have spent an adequate amount of time on board the vessel under test to obtain experience in all aspects of vessel operation. Second the people must have familiarity with other Coast Guard cutters, particularly WPB's, in order to compare the test vessel with current vessels.

For the DORADO tests both of these were initially being met. An experienced WPB crew was to be transferred intact to the DORADO and remain throughout the test period. In practice only a few of the crew were on the DORADO for an extended length of time. Crew replacements in general had no experience with WPB's. As a result the value of the questionnaires suffered badly.

It is recommended that in future OPEVAL's of this nature strict guidelines be established for crewing and that these be adhered to. An alternative approach would be to establish a "panel of experts" who would ride the vessel for a period and then fill out the questionnaires.

APPENDIX D
DESCRIPTION OF INCLINING EXPERIMENT

DESCRIPTION OF INCLINING EXPERIMENT

The inclining experiment on the DORADO was performed in an unconventional manner and hence requires some explanation of the procedures used. The conventional method used to measure the inclination angle is to suspend a long pendulum near a transverse batten and note the lateral movement along this batten. From this the inclination angle can be easily computed. In the case of the DORADO, as with most small vessels, there was no place from which a pendulum could be secured and in any case the pendulum would have been exposed to the wind which would have added considerably to the error.

During the DORADO test the inclination angle was measured using a theodolite on shore and targets set up on opposite sides of the vessel. By measuring the distance from the theodolite to these targets and the vertical angle from the theodolite to each target, the change in heel angle between two loading conditions can be computed. The heel angle was induced by placing two 10,000-pound weights first on the starboard side and then on the port side.

Knowing the vessel displacement, from the draft marks, the inclining weight used, the distance it was moved, and the heel angle, the metacentric height, GM, can be computed.

The theodolite used to measure the angles had a single vertical reticle crossed by 3 horizontal lines. The upper and lower line were equal distance from the center horizontal line. These three lines allow three separate angle measurements to be made which can be averaged for greater accuracy. This permits angle measurements down to 1 second of arc. Measurements are first taken using each of the three lines with the theodolite on one side of vertical. The theodolite is then rotated through a vertical angle of 180 degrees and the three measurements are repeated. These are referred to as face right and face left positions. The six measurement positions are referred to as UL-upper left, AL-average left, LL-lower left, UR-upper right, AR-average right, and LR-lower right. These refer to the reticle line used and the facing of the theodolite.

The six angles above were measured to both targets in each of the two weight locations, port and starboard. The targets themselves were triplane reflector arrays mounted on tripods. These were positioned 37'-1.5" apart on the after main deck. The distance from the theodolite to each target was measured using an infrared ranging device mounted on top of the theodolite. This ranging device could measure the distance down to hundredths of a foot. These distances were also measured for each weight location. This data is shown in Table D-1.

The zenith angle refers to angles measured from the vertical with zero degrees being straight up. Letting Z be the zenith angle then:

$$Z = 1/2\,(360^{\circ} + UL-LR) = 1/2\,(360^{\circ} + AL-AR) = 1/2(360^{\circ} + LL-UR)$$

These three computations of zenith angle can be average to determine the zenith angle to use. For the various targets and weight positions, these work out to be:

Weight	Target	Z	90-Z
Port	Port	$95^{o}55'17''$	$-5^{o}55'17''$
Port	Stbd	$93^{o}26'24''$	$-3^{o}26'24''$
Stbd	Port	$93^{o}04'43''$	$-3^{o}04'43''$
Stbd	Stbd	$95^{o}09'23''$	$-5^{o}09'23''$

The distance from the horizon down to the target is d tan (Z-90) where d is the distance from the theodolite to the target. These distances will be referred to as P_s, port target weight starboard, P_p, S_p, and S_s. The values calculated for these distances are:

$$P_p = 4.3229 \text{ ft} \qquad P_s = 3.3749 \text{ ft}$$
$$S_p = 3.6091 \text{ ft} \qquad S_s = 3.9796 \text{ ft}$$

The heel angle, H.A., can be calculated using the formula:

$$\tan (\text{H.A.}) = \frac{Ss-Sp - Pp - Ps}{D}$$

Where D is the distance between the targets. This gives a value of H.A. of 2.034 degrees. The forward weight and the after weight were each moved 31'0" from port to starboard. Displacement, W, of the SES at the drafts tested was 302,500 pounds. The metacentric height is then:

$$GM = \frac{w \times d}{W \tan (\text{H.A.})} = \frac{20000 \times 31}{302500 \tan (2.034^{o})} = 57.71 \text{ ft}$$

However, no compensation has been made in the above calculation for the effect of the wind. The lateral area of the SES was calculated to be 1250 square feet with the center of area located 7.39 feet above the water line. For a 15-knot wind the side force on this area will be approximately 1200 pounds while the heeling moment due to the wind is:

$$1200 \text{ lbs} \times 7.39 \text{ feet} = 8900 \text{ ft lbs}$$

The total moment must include double this effect due to the way the ship was tested. Therefore:

$$GM = \frac{20000(31) + 2(8900)}{302500 \tan (2.034)} = 59.4 \text{ feet}$$

The amount of weight which can be lifted 5 feet off the side is calculated by:

$$\text{Weight} = \frac{GM * W * \tan (\text{H.A.})}{d}$$

Where d is the distance of the weight from the centerline.

$$\text{Weight} = \frac{59.4 * 302500 * \tan 6^{\circ}}{19.5 + 5} = 77000 \text{ pound}$$

for a 6 degree heel angle.

INCLINING EXPERIMENT

VESSEL NAME USCGC DORADO DATE 8/5/81

TRIAL NUMBER VERTICAL ANGLES	1 MAX PORT PORT TAR	2 MAX PORT STBD TAR	3 MAX STBD PORT TAR	4 MAX STBD STBD TAR
UL	96° 12' 18"	93° 44' 38"	93° 22' 08"	95° 27' 29"
AL	95° 55' 21"	93° 27' 13"	93° 04' 52"	95° 09' 43"
LL	95° 38' 03"	93° 10' 10"	92° 47' 37"	94° 52' 28"
DIST TO PORT TAR	41.68		62.75	
DIST TO STBD TAR	60.04		44.10	
UR	263° 47' 03"	266° 17' 09"	266° 38' 39"	264° 34' 06"
AR	264° 04' 23"	266° 34' 45"	266° 55' 36"	264° 51' 03"
LR	264° 22' 35"	266° 51' 44"	267° 12' 02"	265° 08' 01"

RANGE ADJ SETTING: 42

AIR TEMP: 84

BARO PRESSURE: 30.12

Table D-1

INCLINING EXPERIMENT MEASUREMENTS

APPENDIX E
RUDDER ANGLE DERIVATION

RUDDER ANGLE EQUATION DERIVATION

The test setup was as shown in Figure E-1. This setup was changed slightly between the tests conducted in August 1981 and those conducted in November 1981. The general formula for rudder angle given the voltage input will be computed first and then the constants for the two test periods will be calculated.

String length, a, is proportional to the voltage output across the potentiometer. This is the voltage measured by the test equipment as the indication of rudder angle. Distances b and c are fixed and were measured on board the ship. The angle A corrected to the reference of zero rudder angle is the desired quantity. Length a is linearly related to the voltage so:

$$a = K_1 V + K_2$$

where K_1 and K_2 are constants
V is measured voltage

The following trigonometric identity is of use.

$$\cos(1/2\ A) = \sqrt{\frac{s(s-a)}{bc}} \quad \text{where } s = 1/2(a+b+c)$$

The rudder angle is equal to A - constant angle. Call this constant angle K_3.

The procedure will be to measure a, b, and c at a known rudder angle near zero. From this the value of K_3 can be calculated using:

$$RA = 2*\text{arc}\cos\sqrt{\frac{s(s-a)}{bc}} - K_3$$

$$\text{Since rudder angle} = RA = A - K_3$$

The rudder is then moved to 30° left rudder and the voltage measured. The same thing is done for 30° right rudder. These two rudder angles and voltages are used to calculate constants K_1 and K_2. By manipulating the trigonometric identity the following formula for a is obtained:

$$a = \sqrt{4\left[\left(\frac{b+c}{2}\right)^2 - (\cos 1/2\ A)^2(bc)\right]}$$

$$A = RA + K_3$$

For each of the two rudder angles a can be computed. Then the equations:

$$a_1 = K_1*V_1+K_2$$

$$a_2 = K_1*V_2+K_2$$

can be solved for K_1 and K_2. Working backwards, for any value of voltage the rudder angle is:

$$a = K_1 * V + K_2$$

$$RA = \arccos \sqrt{\frac{(b+c)^2 - a^2}{bc}} - K_3$$

Table E-1 lists the constant values computed for each of the test dates.

TABLE E-1

	August 1981	November 1981
K_1	-6.6003 inches/volt	-4.237 inches/volt
K_2	19.973 inches	19.500 inches
K_3	49.55 degrees	54.75 degrees
b	13.75 inches	14 inches
c	24.75 inches	24 inches

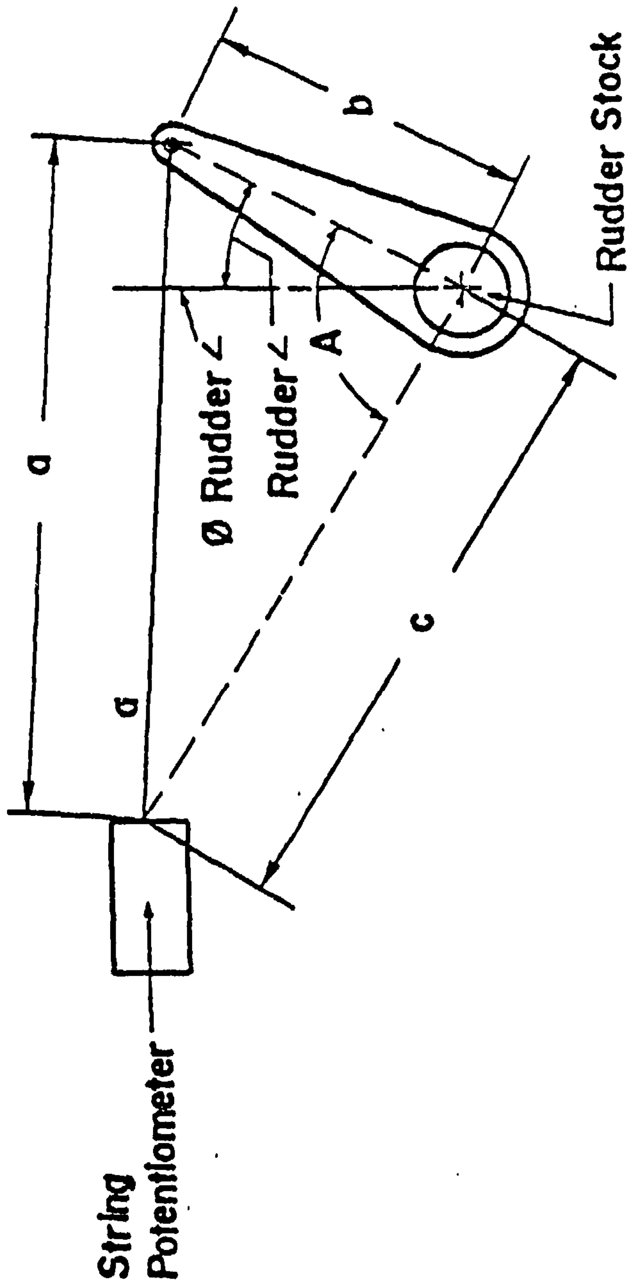


FIGURE E-1
RUDDER ANGLE TEST ARRANGEMENT